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A N
E X A M I N A T I O N
O F
Dr. BURNET's Theory of the Earth :
W I T H S O M E
R E M A R K S
O N
Mr. WHISTON's New Theory of the Earth.
A L S O
An Examination of the Reflections on the
T H E O R Y of the E A R T H ;
A N D
A D E F E N C E of the R E M A R K S ON Mr. WHISTON'S
N E W T H E O R Y.

By J. KEILL, A. M. of Balliol College, O X O N.

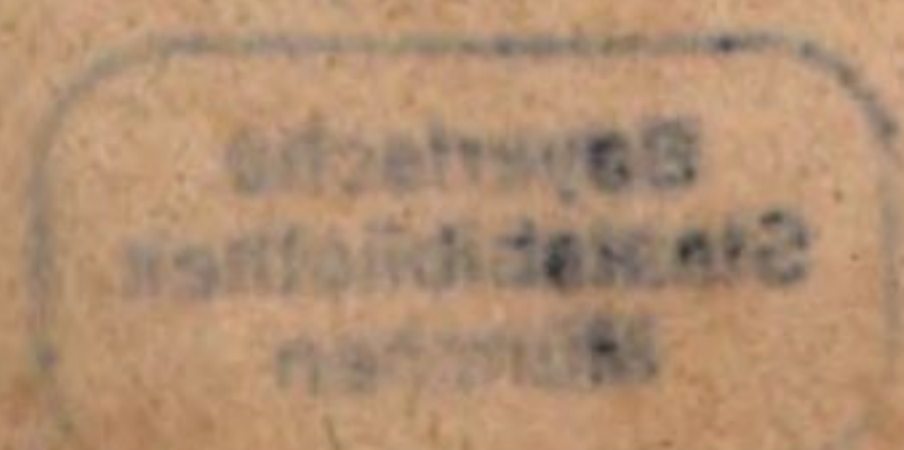
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O N T H E
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With a Summary Exposition of the *Cartesian* and *Newtonian* Systems.

By Monf. de MAUPERTUIS, Fellow of the Royal
Society, and of the Royal Academy in *Paris*.

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M DCC XXXIV.



EXAMINATION

OF

DR. BURNET'S THEORY OF THE EARTH

WITH SOME

REMARKS

ON

DR. WHISTON'S NEW THEORY OF THE EARTH

AND

A CRITICISM OF THE EVIDENCES ON THE

THEORY OF THE EARTH

BY

JOHN BURNET, ESQ. OF THE UNIVERSITY OF EDINBURGH

BY J. BURNET, ESQ. OF THE UNIVERSITY OF EDINBURGH

IN TWO VOLUMES. VOL. I.

LONDON: PRINTED BY J. BURNET, ESQ. OF THE UNIVERSITY OF EDINBURGH

TO THE WHOLE IS ADDED A

DISSEMINATION

OF THE

DISSEMINATION OF THE GOSPEL IN THE

WEST INDIES, BY THE REV. J. BURNET, ESQ. OF THE UNIVERSITY OF EDINBURGH

BY J. BURNET, ESQ. OF THE UNIVERSITY OF EDINBURGH

IN TWO VOLUMES. VOL. II.

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TO THE WHOLE IS ADDED A

DISSEMINATION

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To the Reverend

D^R. M A N D E R

The WORTHY MASTER of
BALLIOL COLLEGE

I N

O X F O R D.

Reverend Sir,



HIS small Treatise
being the Product of
some leasure hours,
I happily enjoy in a
College that is under the
A 2 kind

DEDICATION.

kind influence of your Government, thinks it self obliged to wait upon you, before it dares venture one step further into the world. Its dress I freely own is mean: Nevertheless since the design of it is no other than to shew, that true Philosophy doth not contradict the Scriptures, I am inclined to hope it will find a favorable acceptance among such as have any Concern or Zeal for the advancement of the one, or the security of the other.

The Principles on which I have grounded my Arguments
in

DEDICATION.

in the following discourse being Mathematical, it doth more peculiarly belong to You, whose prudence in so Industriously promoting the Mathematical Sciences, both by your Direction and Encouragement I cannot sufficiently Commend, when I consider what vast improvements have been made, and how many Errors of former Philosophers have been detected by applying Geometry to Natural Philosophy.

I am sensible Sir, how unpleasing it would be if I should Address my self to
You

DEDICATION.

You in the usual stile of Dedications. A prudent Zeal for the Authority of Scriptures, an Hearty Concern for the Rights of the Church, a Tender Care and Unwearied Industry in Promoting the Discipline, Learning, and Interest of an Antient Society, are Virtues which oblige the World to pay You those Praises, which your Modesty will not suffer you to receive. We, who live under the Advantages of these Excellent Qualifications in a Governor, cannot but be sensible of the Obligations we have to be
thankful

DEDICATION.

thankful for them; and indeed the desire of Expressing my Gratitude, for these Common and many other Particular Favors You have been pleased to bestow on me, was the great motive of my presuming to Inscribe this Discourse to your Name; which I desire may be accepted as the result of Duty and Gratitude from,

WORTHY SIR,

Your most Faithful

and most Obliged

Humble Servant,

JO. KEILL.

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For *centrifugal force* (Pag. 91. line 9.) read *centripetal force*, as directed by Mr. Keill in Page 295.

ERRATA in the *Cœlestial Bodies*.

Page 44. line 2. for $p \cdot p :: AC^n$. read
 $p \cdot p' :: CA^n$.

P. 45. l. 7. for $\frac{p \cdot CG^{n+1}}{(n+1) CA^n}$ read $\frac{p \cdot CG^{n+1}}{(n+1) CA^n}$

A N
EXAMINATION

O F
Dr. B U R N E T's

Theory of the Earth.

The Introduction.

WHAT *Plutarch* particularly proves of the *Stoicks*, that they spoke more improbabilities than the Poets, may be extended to a great part of Philosophers, who have maintained opinions more absurd than can be found in any of the most Fabulous Poets, or Romantick Writers. The one as well as the other fancied that their Character did oblige them to say things, which were not common or obvious to vulgar capacities, and therefore scorning the Instructions of sense

B and

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and reason, they only cultivated their own wild imaginations, which seldom produce any thing but what is extravagant and unaccountable. This will soon appear to any who will be at the pains to examin either the Ancient or Modern Philosophers. To begin with the Ancients.

Which of the Poets did ever maintain so ridiculous an opinion, as that it is impossible for Bodies to move? And yet there have been Philosophers (for so they were pleased to stile themselves) who have brought arguments to prove motion to be a thing altogether impossible in nature, and have pretended that these their arguments almost reached the force of demonstration. Is the Fable of *Leda's* being first turned into a Swan, and afterwards placed in the Heavens as a fixed Star, more improbable than the opinion of *Anaxagoras*, that the *Circumambient Æther* being of a fiery substance by the vehement force of its whirling about did tear stones from the earth, and by its own power set them on fire and established them as stars in the Heavens? *Diogenes* another Philosopher said that the Stars were like pumice Stones, and that they were the breathings of the world. But *Xenophanes* the founder of the *Eleatick Sect* says, they are composed of inflamed Clouds which in the day time are quenched, and in the night are kindled again, and that the rising and setting of the stars, is nothing else but the kindling and

and quenching of them. *Anaximander* thought the Sun did very much resemble the nave of a Chariot wheel, which is hollow and full of fire, the fire of which appears to us through its mouth, as by a pipe that is burning. And *Anaximenes* said that when the Sun was eclipsed, the fiery mouth of it was stopp'd and hinder'd from perspiration. *Heracitus* tells us that the eclipse of the Sun was after the manner of the turning of a boat, when the concave as to our sight appears uppermost, and the convex neithermost. Another Philosopher said, that when the Sun was eclipsed, it was extinguished. These indeed are strange notions, but yet they will seem much stranger if we consider that these men lived after *Thales*, who had foretold an eclipse of the Sun by his knowledge that the Moon was to be at such a time in a direct line betwixt him and it. Such an aversion it seems these Philosophers had to build upon other men's observations, that they would rather speak unsufferable nonsense, than be at the pains to consider what was observed before them by wiser men than themselves.

But who without indignation can hear the abovementioned *Xenophanes* maintain, that the earth was founded and rooted in an infinite depth, or *Epicurus* the *World-maker* assert, that the Earth was in the shape of a Drum, and that we dwell upon the plain surface of it, tho', long before either of their times, it was

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demonstrated by the Mathematicians, that the Earth was of a spherical figure, and they had given rules to take the dimensions of it? The same *Epicurus* affirms, in contradiction both to sense and reason, that the Sun, Moon, and Stars are no bigger than they appear to us to be, and for any thing that he knew to the contrary, the Stars might be kindled in the East Quarter and extinguished in the West, or that there might be a new production of Stars every day, so that every day there arose a new Sun. I am sure a Blind man, who had never seen either Sun or Stars, could not have given a worse account of them, than this Philosopher has done; and yet with an unpardonable boldness he pretended to tell us, how the World was made, when it is plain he knew not what it was.

He who desires to know more of the wild notions of the old Philosophers, may consult *Diogenes Laertius*, or *Plutarch's* Books of the sentiments of Philosophers.

But perhaps our Moderns will say, that these indeed were the ridiculous fancies of the old whimsical Philosophers, and it is no great matter what they thought, but that now in this Learned and Inquisitive Age they have at last found out the true and solid Philosophy. They do now perceive the *intimate essence* of all things, and have discovered Nature in all her works, and can tell you the true cause of every effect, from the sole principles

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ciples of *matter and motion*. If you will believe them, they can inform you exactly, how God made the World; for they do now comprehend the greatest mysteries in nature, and understand the Oeconomy of living Bodies: Nay they understand also very exactly the *Theory* of the Soul, how it thinks, and by what methods it operates on the Body, and the Body on it. These indeed are great discoveries, and might well demand our esteem and admiration, if they were real. But that we may see how well they deserve such a Character, I will here set down some of their sentiments, both as to the Intellectual and Natural System.

Spinoza pretends to demonstrate that there is but one individual Substance in the Universe, and that all particular beings are different modifications of the same substance. Another Philosopher, *viz.* Dr. *More*, will have Souls, besides the three dimensions which belong to Bodies, to have a fourth, which he calls the Souls *essential spissitude*, by which it can contract or dilate it self when it pleases. Mr. *Hobbs* thinks Incorporeal Substances a flat contradiction, and that therefore it is altogether impossible there should be any such. But a new * Philosopher has much out-done any I have yet mentioned, in a Book lately Printed concerning Reason; there he assures us that there is but one universal Soul in the World, which is omnipresent and acts upon

*Dr. *Burnet*
thogge.

all particular organized Bodies, and makes them produce actions more or less perfect in proportion to the good disposition of their Organs, so that in Beasts, that Soul is the principle of the sensitive and vital functions; in Men it does not only perform these, but also all other rational actions, just as if you would suppose a hand of a vast extension, and a prodigious number of fingers, playing upon all the Organ-pipes in the world, and making every one sound a particular note according to the disposition and frame of the pipe, so this Universal Soul acting upon all Bodies, makes every one produce various actions, according to the different disposition and frame of their Organs. This opinion he as confidently asserts to be true, as other men believe that it is false; tho' it is impossible he should any other way be sure of it, but by Revelation, and I believe he will find but few that will take it upon his word.

Mons. Malbranch the famous inquirer after Truth, having made a long and deep search how the Soul comes to have its Ideas, has found out at last, that we perceive not the things themselves, but only their Ideas, which the Soul sees in God. "For says he, the
 "Soul is united to God in a much stricter
 "and more essential manner than she is united
 "to the Body; and this union is by his presence, so that it may be said, that God is
 "the

“ the place of Spirits, as space is the place
“ of Bodies. He tells us also, that since God
“ has the Ideas of all beings in himself, the
“ Soul must needs see what there is in God
“ which represents created beings; for Bo-
“ dies are not visible of themselves, they not
“ being able to act upon our mind, nor re-
“ present themselves to it; therefore they
“ being unintelligible in their own Natures,
“ there is no possibility of seeing them, ex-
“ cept in that being, which contains them af-
“ ter an intelligible manner*. Bodies there-
fore and their properties are seen in God, so
that a man who reads this Book does not
really see the Book it self, but only the Idea
of it, which is in God. Is not a man now
much the wiser for this unintelligible jargon?
I would fain know what the Author meant
by his seeing every thing in God by its Idea,
for I must confess that the oftner I read his
long Illustration on this point, I understand
it the less; and I know as little how I
have my Ideas, as I did before. If he had
told me that the Soul saw its Ideas under the
Concave of the Moon's Orb, where they say
Plato placed them, I could have had some sort
of confused notion of that manner of seeing,
but this manner of seeing Ideas, is far beyond
my imagination. I am sure *that I can neither*

* See the Preface and Page 125. first part, and Page 147.
part second. Oxford Edition.

see the Idea of it in God, or any where else ; The truth is, I have not so courageously resisted my senses ; as that Philosopher advises, as to be able to penetrate such a solid piece of nonsense.

The same Philosopher affirms that Bodies of their own nature are neither heard, seen, smelt, nor tasted, and when for example we taste any thing, the Body tasted cannot produce any flavour in us, but God Almighty takes that occasion to stir up that sensation in us, to which the body does not really concur. Nay according to him it is impossible for any man to move his own Arm, but when he is willing to move it, God takes it and moves it up and down, as the man, whose Arm it is, wills. If a Rebellious Son or Subject murder his Father or his Prince by stabbing him, the Man himself does not thrust the Poiniard into his Father's or Prince's Breast, but God Almighty does it, without any other concurrence of the Man but his will. These indeed are strange and unaccountable fancies, But he proceeds still further, and affirms that no second causes act, so that no Body tho' moved with never so great a velocity against another can be able to drive that other before it, or move it in the least, but God takes that occasion to put it in motion. At this rate one need not fear his headpiece tho' a Bomb were falling upon it with all the force that Powder can give it, for it could
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not so much as break his Skull, or finge his hair, if God did not take that occasion to do it. The most natural agents with him are not so much as instruments, but only occasions of what is produced by them, so that a man might freely pass thorough the fire, or jump down a precipice without any harm, if God Almighty did not take that occasion to burn him, or dash out his brains.

To prove that our moderns are as wild, extravagant, and presumptuous as any of the Ancients either Poets, or Philosophers, I may instance in Dr. *Conner*, whose imagination has taken a flight beyond the spheres of sense and reason. Other Philosophers were only ambitious to explicate nature, and the common effects of it, but no less a subject can satisfy him, than the Omnipotent Author of nature, and his extraordinary and miraculous acts, which he pretends to explain, for he thinks he understands them as well as he does the common Phænomena of Nature. This I believe will be granted him without much difficulty, for there is very good reason, to believe, that the works of Nature, are as much hid from him, as the mysteries of it, which he treats of, are from others. And tho' he talks that he has well considered the Laws of motion, and the force of Nature, yet it is plain that he knows not how to determine what proportion of motion there is in two bodies whose bulks and velocities are given. One can neither

ther be the wiser or better for what he has written, except to be convinced of the reasonableness and excellency of modesty and humility, seeing his attempts are as unsuccessful, as they are shamefully impudent. And yet his Book must have the Sacred name of *Evangelium* prefixt to it, for which the Divines should severely Chastise him, to whom I leave him.

But M. *Des Cartes* the great Master and deliverer of the Philosophers from the tyranny of *Aristotle*, is to be blamed for all this, for he has encouraged so very much this presumptuous pride in the Philosophers, that they think they understand all the works of Nature, and are able to give a good account of them, whereas neither he, nor any of his followers, have given us a right explication of any one thing. So ridiculous are the things he has delivered in his principles of Philosophy, that it is a wonder how they should be believed by any, but it is still a greater wonder how they came to be so much applauded and received among the Learned, as they were. I will here set down some of the strange Schemes and unaccountable fancies of this Philosopher. He assures that there is always the same quantity of motion in the World, so that if all the Men and Animals in the World were moving, which most part of them can do when they please, yet still there would be no more motion in the World than there is in
the

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the night time when they are at rest, and what motion they had when they were moving, must be communicated to the Æther when they are at rest. Another opinion of his about motion, as strange as the former, is this, if there be two contiguous Bodies, A and B; and if B, were carried towards C, by the



very same Action A is transferred from B; so that there is an equal quantity of motion, and action, in both, tho' to all men's senses, the body A seems not to be moved at all. Another law of motion, as contrary to sense as any of the former, is; that if there be two bodies, one of which is bigger, tho' by a very little than the other, the lesser, tho' moved with never so great a velocity against the former, which is at rest, can never put it in motion. Notwithstanding these and many other of his absurd notions, he had a strong party of the Philosophers on his side, and great was the outcry against *Aristotle*, for his tyrannical usurpation of the liberty and property of the Philosophers to think and say what they had a mind; tho' what they said was much more absurd than *Aristotle's* ἐντελέχεια, or the Schoolmen's

men's substantial formes, which much give way to *Monf. Des Cartes's* ingenious hypothesis, who, as his followers pretended, could solve all the phænomena in nature, by his principles of matter, and motion, without the help of attraction and occult qualities. He was the first world-maker this Century produced, for he supposes that God at the beginning created only a certain quantity of matter, and motion, and from thence he endeavours to shew, how, by the necessary laws of *Meckanisme*, without any extraordinary concurrence of the Divine Power, the world and all that therein is might have been produced. Nay he was so bold, that he pretended he could solve that insuperable problem, *viz.* having a quantity of matter and motion to produce any animal. But with what confidence could he pretend to solve so intricate a problem, who blundered so much in the easiest and most abstracted things in nature, (for such are the laws of motion) that of the seven rules he has given us about motion, there is but one of them true.

I wonder therefore why *Mr. Wotton* in his reflections on ancient and modern Learning, “ should say that *Des Cartes* joined to his
 “ great genius an exquisite skill in Geometry,
 “ so that he wrought upon intelligible principles, in an intelligible manner, tho’ he
 “ very often failed of one part of his end, namely
 “ a right explication of the Phænomena of
 “ nature, yet by Marrying Geometry and
 “ Phy-

“Phyicks together, he put the World in
“hopes of a Masculine offspring. This I think
is a clearer demonstration than any in *Des
Cartes’s* principles of Philosophy, that Mr.
Wotton either understands no Geometry, or
else that he never read *Des Cartes’s* principles,
for from the beginning to the end of them
there is not one demonstration drawn from
Geometry, or indeed any demonstration at all.
Except Mr. *Wotton* will say, that every thing
that is illustrated by a figure, is a demonstra-
tion, and then indeed he may produce enough
of such demonstrations in his Philosophical
works. So far was *Des Cartes* from Marrying
Phyicks with Geometry, that it was his great
fault that he made no use at all of Geometry
in Philosophy. It may perhaps be thought that
he understood Geometry as well as most of
his contemporaries, and therefore Mr. *Wotton*
might have presumed, that he ought to have
joined Geometry to natural Philosophy, but
since he asserts that he actually did so, I think
it a convincing argument that he makes him-
self a judge of things he does not understand.
But what he falsely ascribes to *Des Cartes*, is
really true of *Galileo* and *Kepler*, who, by the
help of Geometry have discovered Physical
truths that are worth more than all *Des Car-
tes’s* Volumes of Philosophy, who was so far
from applying Geometry and observations to
natural Philosophy, that his whole System is
but one continued blunder upon the account
of

of his negligence in that point. This I can easily prove by shewing that his Theory of the *Vortices*, upon which his Systeme is grounded, is absolutely false. The great Philosopher of this age, the most Ingenious and Incomparable Mr. *Newton* by his great and deep skill in Geometry, has shewed that the periodical times of all Bodies which swim in *Vortex*, must be directly as the squares of their distances from the center of the Vortex. But it is evident from observations, that the Planets in turning round the Sun, observe quite another sort of a law than this, for the squares of their Periodical times, are always as the cubes of their distances, and therefore since they do not observe that law, which of necessity they must, if they swim in a *Vortex*, it is a demonstration that there are no vortices, in which the Planets are carried round the Sun.

Besides if the earth were carried in a *Vortex*, it must necessarily move faster, when it is in the beginning of *Virgo*, where the fluid is in a narrow space, (and by consequence moves so much the swifter,) than it would do when it is in the beginning of *Pisces*, and that in the proportion of three to two, which is directly against experience, and observation.

It is impossible therefore upon this, and a great many other accounts, which Mr. *Newton* has shew'd in his principles, that the earth and the other planets can move in a *Vortex*. So that the notion of a *Vortex* being ruined, the whole

whole *Cartesian* system must of necessity fall to the ground ; and that world, whose origination he pretended to have deduced from Mechanical principles, must be a wild chimera of his own imagination.

I cannot pass without reflecting upon another great error in the *Cartesian* Philosophy, which he committed purely for want of due observations. And that is, his reason why at the Moon's opposition, or conjunction with the Sun, the Tides should be greater than at her quadratures. To explain this, he makes the Moon move round the earth, in an Ellipsis, in whose centre the earth is placed, so that by this means, the Moon will have two *Apogeons*, and two *Perigeons*, and he says that the Moon is in one of her *Perigeons* always at the time of her opposition, or conjunction, and by this means she presses then more strongly upon the Sea, than she does at her quadratures, at which time according to him she is always in one of her *Apogeons*, and therefore her pressure must be weaker. All this is so notoriously false, that there is no Almanack-maker but can demonstrate the contrary, and if he had but in the least considered the Theory of the Moon, he might easily have seen that the Moon is as often in her *Apogeons* at new and full Moon, as she is in her *Perigeons* at that time, tho' it seldom happens at the lunations that she is exactly in either.

By

By this it may sufficiently enough appear, that the most ingenious thoughts in the Cartesian Philosophy, are false, and disagreeable to nature, which I have shew'd not only because the Philosophers of that sect have pretended to so very great things, as to give a true account of all the Phænomena's in nature, whilst they understand so very little, that they have not given us a right explication of any one thing ; but also because Mr. *Des Cartes*, the author of that Sect, was the first who introduced the fancy of making a World, and deducing the origination of the Universe from Mechanical principles. Which notion has been so stiffly maintained by his admirers, that by it they have given the ignorant Atheists (for so are most of that persuasion) some plausible pretences for their incredulity without any real ground.

But of all Philosophers, those have done Religion the least service, who have not only asserted, that the world was made by the laws of Mechanism, without the extraordinary concurrence of the Divine power, but also that all the great changes which have happened to it, such as the Deluge, and other great effects delivered to us as miracles by the sacred writers, were the necessary consequences of natural causes, which they pretend to account for. These contrivers of Deluges, have furnished the Atheist with an Argument, which upon their supposition is not so easily an-

answer'd as their Theories are made. Which is this.

The World they will say, was never either made or created by God in time, but did exist from all eternity, without any change, or alteration, but such as happened from pure Mechanical principles, and causes, and the true reason, why there remain no records; or traditions of facts done in the time beyond four or five thousand years, is because there has happened a Deluge, the memory of which is still preserved, and this Deluge being the necessary consequence of natural causes, did sweep away all mankind, and with them the memorials of all former ages, only a couple of ignorant country people some way or other, saved themselves from the universal Catastrophe, and from their offspring the earth was again replenished, and arts and sciences invented, which our forefathers before that deluge understood more perfectly than we do now.

This they will tell you is their hypothesis, and they will not be beaten easily from it, since it may be defended as well, as any other Philosophical Theory which pretends to give an account of the origination of the World, and is as precarious as their own system of principles which they pretend is very possible, since several Philosophers have shew'd various ways, how there might have happened so universal a deluge, from Mechanical

nical principles, and the necessary laws of motion.

Thus we see how these flood-makers have given the Atheists an Argument to uphold their cause, which I think can only be truly answer'd by proving an universal Deluge from Mechanical causes altogether impossible. And therefore I design to shew that the most ingenious Theories fram'd upon that account, come far short of the design of the Framers, and that the great and wonderful effects, which they endeavour to explain, could never have risen from the causes they assign.

This I intend to do by shewing that their Theories are neither consonant to the established laws of motion, nor to the acknowledged principles of natural Philosophy, of that Philosophy I mean, which is founded upon observations and calculations, both which are undoubtedly the most certain principles, that a Philosopher can build upon. It is in vain to think that a system of Natural Philosophy can be framed without the assistance of both, for without observations we can never know the appearances and force of nature, and without Geometry and Arithmetick we can never discover, whether the causes we assign are proportional to the effects we pretend to explain. This the various systems of the Philosophers do evidently shew, which are by far more distant from the truth, than

than they are from one another. And I hope it will appear yet plainer by the following examination of Dr. *Burnet's Theory of the Earth*. Which tho' it has been published many years, and has been animadverted upon by several, yet it has not been so fully refuted as it might have been, nor has any one shew'd the greatest mistakes in it. Nay, Mr. *Erasmus Warren*, who has wrote the greatest Volum against it, in my opinion has spoken the least sense about it.

He begins his discourse with a saying of an old Heathen, that Philosophy is the greatest gift that ever God bestowed on man. Which I will not deny, since he has been at so much pains to make a Panegyrick on the usefulness of it. But it is plain to any who will be at the pains to read his Book, that God has thought fit to bestow but very little of that great gift upon him. And that the world may not think that this is said out of ill nature and without grounds, I will give them a tast of his Philosophy, Geometry, or Geography, (call it which you please.) He designs to calculate how much colder the *Poles* would be if the earth were of an Oval figure, than if it were perfectly Spherical. To do which he supposes that a Circle formed into a moderate Oval, will have its *Poles* at least a fortieth part farther distant from the *æquator*, than if it were perfectly spherical. "Now according to this proportion,

C 2

"allowing

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“ allowing the earth to be 7000 miles in
 “ Diameter and adding a fourth part to ren-
 “ der it Oval, viz. 1750 miles thickness;
 “ the earth at each Pole must bear above
 “ fourteen degrees latitude more than if it
 “ had been round. So that the hypothesis
 “ which removes its Poles so much farther
 “ from the Sun, must also allow the cold
 “ thereabouts to be proportionably augment-
 “ ed. *And tho’ in the hundred and fourth de-*
 “ *gree of latitude* (as we must call it,) on
 “ each side of the *æquator*, that is, at the
 “ very Poles, there might have been a per-
 “ petual day, &c. *

This is the first time I ever heard that
 there could be more than ninety degrees be-
 tween the pole and the æquator, but he thinks
 he has fairly made it out that there can be
 a hundred and four degrees between them,
 and therefore, there must be four hundred
 and sixteen degrees in the whole circumfe-
 rence, and then, every right angle being on-
 ly proportional to ninety degrees, there
 must be more than four right angles about
 one point, and therefore the Corollary of
 the 13th of the first of *Euclid* must be false.
 Thus has that subtle Philosopher not only
 subverted Dr. *Burnet’s Theory*, but also *Eu-*
clid’s demonstrations, and that by an argu-
 ment which the dull Mathematicians could
 never discover.

But

* *Warren’s Geology* page 116.

But I will leave *Euclid* to his mercy, and answer that part of his argument that concerns the *Theory*: which is easily done, if he will consider that the difference between the *poles* of the earth's distance from the Sun, and the *æquator* of the earths distance from the Sun, even tho' the earth were ten times more Oval than he would have it, is so very inconsiderable that it does almost bear the same proportion to the whole that a point does to a line, for the Mathematicians know that the diameter of the earth is but a point, in respect of its distance from the Sun, and therefore two lines drawn from the Suns centre to any two points of it are very near in a proportion of equality, so that upon the account of a greater or lesser distance of the parts of the earth from the Sun, there can be no sensible alteration of heat or cold.

But I am afraid this is a little too far beyond Mr. *Warren's* capacity, however to surprise him a little more, I will tell him, he is so far out in his account of the cold at the *poles*, that tho' the North *pole* be much colder in the Winter than it is in the Summer, yet it is some hundred thousands of miles nearer to the Sun in Winter than in Summer. If he pleases to consult the Astronomers, they can demonstrate the truth of this to him.

I beg Mr. *Warren's* pardon for bringing him into this place, I ought to have been favourable to him, he being one of my Affo-

ciates against Dr. *Burnet*. But I was willing to produce him as an instance, to shew how unfit a man who understands no *Geometry*, is to write a book of *Natural Philosophy*.

But to return to the *Theory*, I cannot but acknowledge, that there was never any book of Philosophy written with a more lofty and plausible stile than it is, the noble and elegant descriptions the Author gives the subject he treats of, shew that he has a great command of Language. His Rhetorical expressions may easily captivate any incautious reader, and make him swallow down for truth, what I am apt to think the Author himself, from the sacred character he bears, designed only for a Philosophical Romance, seeing that an ordinary Examination thereof, according to the laws of Mechanisme cannot but shew, that he has acted the part of an Orator much better than he has done that of a Philosopher. For in reality none of these wonderful effects, which he endeavours to explain, could have proceeded from the causes he assigns. And to demonstrate this is the design of this small Treatise, in which I will not inquire how far the *Theory* is agreeable to Holy Scriptures, that being a work already done by others, who I presume understand that Subject better than I do, neither will I confine my self to follow the Author from Chapter to Chapter, and find Fault with every thing contain'd in the
Theory

Theory, least it should look more like spitefulness and ill nature than a diligent search after Truth. My design therefore is to choose out some of the principal heads of the Theory, and having shown them to be false and disagreeable to the laws of Mechanisme, the rest must all fall to the ground of course.



 C H A P. I.

*An Examination of the Theorists
general Argument which he uses to
prove the Truth of his Theory.*

IN the second and third Chapters the Theorist makes way for an Argument which he alledges in his seventh to prove the truth of his Theory, viz. that all other wayes for the explication of *Noah's Flood* are false and impossible, and that he has given the only possible, and consistent Idea of an universal flood, and therefore it came to pass the way he has assigned and no other. This Argument we see is founded upon two Propositions. 1st. That no other way is possible, and 2^{dly}. That his own Theory is an intelligible and consistent explication of the universal flood. This last Proposition I intend to examin in the following Chapter, and the first in this.

The Theorist, to prove all the common ways of explicating the universal deluge false and impossible, Calculates the quantity of
water,

water, which would be sufficient to cover the whole Earth, above the Tops of the highest Mountains, and finds that no less than eight Oceans of water could be sufficient for such a Work. Now it is certain (says he) that such a stock of waters could neither come from the Sea, the Rain, or subterraneous Caverns, and Channels of the Earth, there being no such quantity of water in Nature, as would be requisite for such a Purpose: and therefore the explication of the deluge from these causes is impossible. Neither will he allow any supercelestial waters to make up the eight Oceans necessary for the deluge. For if there were any such waters, the Heavens above where they lay must be either solid or fluid. If solid as Glass or Chrystal, how could the waters get thro' them to descend upon the earth? If fluid as the Air or *Æther*, how could the waters rest upon them, it being heavier than Air? But if you will suppose, that waters were brought down from this imaginary region, to drown the world, in that vast quantity that would be necessary, what became of them when the deluge ceased? It would be a hard task to lift seven or eight Oceans of water up among the spheres, and there is no room for them here below. Thus the Theorist thinks, that the vulgar opinion makes the deluge impossible and unintelligible upon a double account, both in requiring

quiring more water than can be found, and more, if found, than can be dispos'd of.

This is the sum of the Theorist's Argument, why all other methods and explications of the deluge are false, and impossible, which I have here related, because I think it an evident demonstration of the impossibility of all *Natural* and *Mechanical* explications of the deluge whatsoever, even his own not excepted, as I shall shew in its due place: it being impossible for Nature, not assisted with extraordinary divine power, to bring so much water upon the earth; and if it were once brought, it is as impossible to remove it.

But all this does no way prove, that the deluge might not have been brought upon the earth by the Almighty power of God. Cannot he bring out the waters from the deep or the *Abyss* as from a Storehouse, and sustain them from running down again with the same ease he made the waters of the *Red Sea* stand on a heap, while the *Israelites* passed through? Is any thing of this nature too hard for the Almighty to perform? Might not he, if there were not enough in the abyss, bring water on the earth from the Heavens above, which might have been there from the Creation notwithstanding the Theorist's question, How could they rest there? Since the same power might keep them in their place, that detains the Moon or any other of the Planets in their orbits; and perhaps from some
of

of these, or from other places best known to the Divine wisdom, some of this water was brought upon the earth, and afterwards remov'd by the Omnipotent hand of God who only worketh great wonders. Is not this a much easier and shorter account of the deluge than the Theorist's, which is built upon false and precarious principles, and inconsequential conclusions, which after all will not be sufficient to produce the desired effect?

But it seems the Theorist is not very willing to acknowledge that God Almighty had any hand in that great Catastrophe of the world, tho' it be plainly told us in Scripture that he was the immediate Author thereof, *Gen. 6. 17. Behold, (saith God) I, even I, do bring a flood of waters upon the earth.* Nor do I see any reason why he ought not to acknowledge the universal deluge of the world to be Miraculous, as well as the destruction of *Sodom* and *Gomorrab* was by raining of Fire and Brimstone; since they were both sent as punishments for the sins of men: neither of which, without doubt, had ever happened if man had continued in the state of Innocence.

The Scriptures give us an account of several Miracles wrought by the hand of Omnipotence upon occasions, which did not so necessarily require them. Why ought we then to deny this universal destruction of the earth to be miraculous? Miracles are the great
and

and wonderful works of God, by which he sheweth his Dominion and Power, and that his Kingdom reacheth over all, even Nature her self, and that he does not confine himself to the ordinary methods of acting, but can alter them according to his pleasure. Were not they given us to convince us of the sacred truths contained in holy Scripture? Was it not by the demonstrative force of Miracles that *Moses* and the Apostles proved their divine Mission, beyond all that other Framers of Religions could pretend to? And tho' our holy Faith stands so well confirmed by real miracles, that we are neither to make nor admit of any false ones, yet certainly we are not to detract from the value of the true ones, by pretending to deduce them from *Natural* and *Mechanical* causes, when they are no ways explicable by them. It is therefore both the easiest and safest way, to refer the wonderful destruction of the old world to the Omnipotent hand of God, who can do whatsoever he pleases.

C H A P.

C H A P. II.

Of the Chaos.

TH A T the Earth was formed from a *Chaos*, must be unquestionably own'd by all, who acknowledge the Holy Scriptures, for they tell us, that in the beginning *the Earth was without form and void, and darkness was upon the face of the deep*: which is a most excellent description of that *Chaos*, from which the world arose. From it therefore the Theorist begins to frame his Antediluvian earth by the sole help of Natural and Mechanical causes. He supposes the *Chaos* to be the matter of the earth and heavens, without form or regularity, reduc'd into a fluid Masse, wherein are the materials and ingredients of all Bodies mingled in confusion one with another, without any order of higher or lower, heavier or lighter, solid or volatile. The first change he imagines that did happen to this Masse, was, that the heaviest and grossest parts sunk down towards the middle of it (for there he supposes the Center of its gravity) and constituted the hard and solid

lid interior part of the earth. The rest of the Masse which swam above, was also divided by the same principle of gravity into two orders of bodies, the one liquid like water, the other volatile like air. For the fine and active parts disintangling themselves by degrees from the rest, did mount above them, and having motion enough to keep themselves upon the wing, did play in these open places, where they were to constitute that body we call Air: the other parts being grosser than these settled in a Masse together under the air, upon the body of the earth, composing not only water strictly so called, but the whole Masse of liquors and liquid bodies belonging to the earth; of which there were two kinds, one of which is fat, oily and light, and the other lean and more earthy, like common water. Now it being well known that these two liquors mixed together, if left to themselves and the general action of nature, separate one from another, as in Cream and thin Milk, Oil and water, and such like: So we cannot doubt but that the same effect would follow here, and the more oily and light parts of this Masse would get above the other and swim upon it. Thus would the whole Masse of liquids be divided into two lesser Masses.

Now if we look over again these two great Masses of Air and Water, we cannot but imagine, that they were both at first very muddy
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and impure : for the air was yet thick, grosse and dark, there being abundance of terrestrial particles swimming in it still, after the grossest were sunk down, and the lesser and lighter, which remain'd in the Air, did sink too, but more slowly. So that in their descent they did meet with the oily liquor upon the face of the deep, which did intangle and stop them from passing any farther, so as mixing there with that unctuous substance, they did compose a certain slime, or fat, soft earth, spread upon the face of the waters. And this thin and tender Orb encreased more and more as the little earthy particles detain'd in the air could make their way to it; and mingled with that oily liquor, till at length they suck'd it all up, and were wholly incorporated together : which was the first concretion and firm consistent substance upon the face of the Chaos.

After this fashion has the Theorist formed his Antediluvian habitable world, which doth not much differ from the *Cartesian* method of making the earth, only *Des Cartes* being somewhat wiser than the Theorist, would not allow the outward crust, within whose bowels the waters were shut up, to be a habitable earth, knowing well that neither man nor beast could live long without water. But he made the crust first broken, and the waters flow out, before he plac'd any inhabitants on it. Another small difference betwixt the two hypotheses, is,

is, that *Mons. Des Cartes* never thought of making the exterior Orb of oily liquids, which the Theorist asserts to be absolutely necessary towards the formation of the crust. For if it were not, says he, for the oily liquor which swims upon the surface of the Abyss, the particles of earth which fell thro' the air had sunk to the bottom, and had never formed the exterior Orb of earth.

But notwithstanding this, I believe it may be easily made evident (tho' neither of their Systems are true) that the Theorist's hypothesis is the worst of the two. Which I will prove from his own concessions: for he has already own'd that the oily liquor is much lighter than the watery Orb. He has mentioned also that the terrestrial particles when falling from the air, if the Orb were only water, would sink to the bottom; and therefore those particles must be heavier than water. From thence, I think, it does necessarily follow, that those terrestrial particles must also be heavier than the oily fluid which is lighter than water, and therefore they will more easily descend thro' it than they did thro' water, it being well known that there are several bodies which will swim in water, but sink in oil.

But that which seems to have deceiv'd the Theorist in this point was, that he had observed that small dust, tho' specifically heavier than oil, yet being thrown upon it, it did not sink, and therefore he concluded, that a great
deal

deal of it, if cast upon the Surface of oil, after the same manner, would not descend, but form a solid concrete substance upon the surface of the oil. But this consequence will soon appear to be false, if we consider the true reason why some bodies, tho' specifically heavier than the fluid in which they are put, do not sink, but swim upon the surface: which is this; That there is scarce any liquid in nature which is absolutely fluid, and whose parts do not resist separation one from another, and therefore will somewhat hinder or retard the descent of bodies thro' them. Now this resistance (all other things being alike) is always proportional to the surface of the body descending: so that small bodies, whose weight or force to move or separate the parts of the fluid, is but very little, may have a surface so large, that they cannot overcome the resistance of the fluid; that is, they cannot make way for their descent thro' the fluid, and therefore must swim upon the surface of it: but the surfaces of bodies not increasing in the same proportion with their solidities or weights, small bodies will have a greater resistance in proportion to their weight, than greater ones of the same intensive gravity, and consequently the one will descend when the other cannot. As for example, suppose a sphere of an inch diameter was put into an oily fluid, whose resistance was just equal to the force of gravity in the descending body: there being an æquilibrium

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librium, the former would swim in the latter. Now if another sphere of two inches diameter, and of the same intensive gravity were put in the same fluid, its gravity or force by which it would separate the particles of the fluid, would be eight times greater than the descending force of the former sphere; and if its resistance were also eight times greater, it is plain that it also could not descend: but the resistance being always (as I noted before) as the surface of the descending body, is only in the present case four times greater; which will not equal the force of its gravity, and therefore the sphere must descend. So in our present case, tho' some small grains of dust or earth may swim upon the surface of Oil, yet these when increas'd by the addition of a great many others which fall upon them, augment their weight (the same resistance continuing) and must fall to the bottom.

Besides this, the earthy particles falling from a great height, some of them descending from places as high as the Moon, as the Theorist will have them, must needs in their descent acquire a very considerable degree of velocity, with which falling upon the surface of the oily Orb, they will not only by that force descend themselves, but also carry down with them, and condense whatsoever bodies they met in their way or found swimming upon the surface of the oil. Now that the
force

force of a descending body is so great as to perform this effect, I think, is clear to any who considers that a heavy body runs down fifteen foot in a second, and that the spaces thro' which it does move, are always in a duplicate proportion to its times, as is demonstrated by *Galileo*, and confirmed by the Experiments of *Riccioli*: from whence by calculation it will follow that a body would run down four thousand miles in the space of twenty three seconds, abstracting from the resistance of the air. But if we will suppose but the hundredth part of this space run thro' in that time, allowing all the rest for the resistance of the Medium, yet even in that case, the velocity would far exceed that of the swiftest bullet, that can be shot out of a Cannon.

Thus, I think, I have made it evident, that the particles of earth after falling thro' the air, could not rest upon the surface of the oily Orb, to form there an hardened habitable Crust, not only upon the account of their greater gravity, which the Theorist acknowledges, and is also plain by experience, common earth being near twice as heavy as water; but also upon the account of the great force by which they must of necessity fall upon the liquid Orb, which will carry them down towards the Center.

I hope now it will appear to any thinking man, plainly impossible, that either oil

or water should sustain such an immense heavy Orb, in which was not only the soft earth, which in few places is ten foot deep, but also a prodigious quantity of stones and minerals much heavier than water: for it is certain that these great heavy bodies must have sunk to the bottom if they were left to themselves, and yet even these bodies make up the greatest part of our outward earth. I know the Theorist does boldly affirm, that there was neither Metals nor Minerals in the primitive earth; but this is both contrary to reason and Scripture, for the Holy Scriptures tell us, that *Tubal Cain* before the flood, was an instructor of every Artificer in Brass and Iron: and I would fain know, how there could be such Artificers before the flood, when, according to him, there was no such thing to be seen as Metals. Besides, 'tis hardly possible to build an Ark, that should contain all the terrestrial and aerial animals, without Iron. The *Americans* without any Iron made themselves small Canoes of one solid piece of Timber which they hollowed by burning, but it would be a strange Tree that was of the dimensions of the Ark, and could contain so many animals as it did. These things do (in my judgment) plainly show, that the Theorist's opinion in this point is utterly false.

From what I have already said, I think, it may be clearly demonstrated, that the Fabrick of the earth can never be deduced from a
Chaos,

Chaos, by the sole help of Mechanical principles and Natural causes. For it is evident to any one who has eyes (tho' there have been some wise Philosophers of another opinion) that the Land is higher than the Water; and it is also plainly experienced, that common arable earth or clay is much heavier than water: and if we descend into the Mines or Pits, we shall find the matter there to be three or four times heavier than the earth above. Now it is plain from what I have already proved, that in a Chaos, the true change that would follow from Mechanical principles and Natural causes, is, that if all were fluid, the heaviest and solidest Bodies would subside and fall to the Center, every one taking place according to the specifick gravity; so that the lighter Bodies would always be forced uppermost: the earth therefore being heavier than the water, must of necessity place it self nigher the Center, and leave the water to cover the face of the whole Orb. Thus the surface of the World could never be inhabited by any other Animal than Fishes. But in how much wiser order than this, has the great Creator of the World placed all the Bodies of the earth, so that notwithstanding the greater gravity of the Land, it is raised higher than the Sea, and thereby made fit and habitable both for man and beasts, without the help of Natural and Mechanical causes, which would have produc'd the contrary effect.

Several other arguments might be brought to demonstrate that the frame of this World was the result of wisdom and counsel, and not of the necessary and essential Laws of motion and gravitation, which could never have either made or supported the World. I always wonder'd at the wild an extravagant fancy of the Philosophers, who thought that brute and stupid matter would by it self, without some supreme and intelligent director, fall into a regular and beautiful structure, whose parts should be so extreamly well adapted to various uses, as if they had been the result of wisdom and contrivance. I will conclude this Chapter with a discourse of the Theorist in his 10th Chap. lib. 2.

“ In the construction of the Body of an
“ Animal, (says he) there is more of thought
“ and contrivance, more of exquisite inventi-
“ on, and fit dispositions of parts, than is in
“ all the Temples, Palaces, Ships, Theaters, or
“ any other pieces of Architecture the World
“ ever yet saw, and not architecture only,
“ but all other Mechanism whatsoever, En-
“ gines, Clock-work, or any other is not
“ comparable to the Body of a living crea-
“ ture. Seeing then we acknowledge these
“ artificial works wheresoever we meet with
“ them, to be the effects of wit, under-
“ standing and reason; is it not manifest
“ partiality or stupidity rather, to deny the
“ works of nature, which excel these in all
degrees,

“ degrees, to proceed from an intelligent
 “ principle? Let them take any piece of hu-
 “ man art, or any Machine fram’d by the
 “ wit of man, and compare it with the Body
 “ of an Animal, either for diversity and mul-
 “ tiplicity of workmanship, or curiosity in
 “ the Minute parts, or just connexion and
 “ dependance of one thing upon another, or
 “ fit subserviency to the ends propos’d of Life,
 “ Motion, Use, and Ornament to the creature:
 “ and if in all these respects, they find it su-
 “ perior to any work of human production,
 “ as they certainly must, why should it be
 “ thought to proceed from inferior and sense-
 “ less causes? ought we not in this as well
 “ as in other respects to proportion the causes
 “ to the effect, and to speak truth, and bring
 “ an honest verdict for Nature as well as for
 “ Art?

I desire the Theorist may apply this ex-
 cellent discourse to himself, and consider whe-
 ther this Argument which he produces against
 the *Epicureans* and *Atheists*, does not fully
 shew the absurdity of his own Theory.

C H A P. III.

Of the Mountains.

TH E Theorist frames his *Antediluvian* Earth, smooth, regular and uniform, without Mountains, and without a Sea. The proof which he brings for this bold assertion, is, that the Globe of the Earth could not rise immediately from a Chaos into the irregular form, in which it is at present; the Chaos, says he, being a fluid Masse, which we know does necessarily fall into a spherical surface, whose parts are *equidistant* from the Centre, in an equal and even convexity one with another. And since upon the distinction of the Chaos, and separation into several elementary masses, the Water would naturally have a superior place to the Earth, 'tis manifest there could be no habitable Earth form'd out of the Chaos unless by some concretion upon the face of the Water. Then lastly seeing this concrete Orb of Earth upon the face of the Water would be of the same form with the surface of the Water it was spread upon, there being no causes that we know of, to make an inequality
in

in it, we must conclude it equal and uniform, and without Mountains, as also without a Sea. For the Sea and all the Masse of Water was inclos'd within this exterior Earth, which had no other basis or foundation to rest upon.

This is the Theorist's great argument why the face of the primitive earth was smooth and uniform and without Mountains; which if we consider narrowly, it will appear to depend upon a precarious and false supposition, namely that the great Masse of matter which we have now for our earth, was, when in a Chaos, an entirely fluid Masse, which is a hard thing to be granted, since the greatest parts of Bodys we have in the earth, at least so far as we can discern, are hard and solid, and there is not such a quantity of water in the earth, as would be requisite to soften and liquify them all. Besides, a great part of them, as Stones and Metals, are incapable of being liquified by water. We must conclude therefore that the Chaos was not so fluid a Masse, as would be necessary for to have its surface even and uniform. Why might not there have been in this great Masse huge lumps of firm and solid matter, which without any form, order, or regularity, might be jumbled together, and swimming up and down, some on the surface, and some within the fluid? I will leave it to any to judge which appears most like a Chaos, this which I have describ'd, or his, which is a regular, uniform fluid of a spherical figure,
so

so compos'd and mix'd with all Bodies that no part of it, at least at the same distance from the Centre, is thicker than another: which must necessarily fall out, if the Chaos had an exact spherical figure, as the Theorist supposes. If it were otherwise, it is plain by *Hydrostatical* Principles, that there the fluid would rise highest, where it is thinnest, or lightest; and consequently it would not have its surface uniform, equally even and distant from the Centre.

Indeed, methinks the Theorist's first figure of the Chaos, does very much contradict his own hypothesis. There you may see represented great pieces of hard and solid matter of no regular figure, swimming confusedly in the fluid; any one of which seems to bear a far greater proportion, to the whole Masse; than the highest hills could do to the whole Earth.

But perhaps it may be said that all these hard and solid Bodies being heavier than the fluid in which they swam, fell down and compos'd the Central solid. And so far I must own indeed, that all the Bodies in that great Masse, which were heavier than water, if left to the laws of gravity, would necessarily fall down toward the Centre. But certain it is that in such a great heap of matter, and so different mixtures of all sorts,

Mollia cum duris, sine pondere habentia pondus.

there

there must be several that were specifically lighter than the water in which they swam, and therefore after that the heaviest had fallen to the Centre, they would still float upon the surface, so much of them being under water as would equal in quantity a bulk of water of the same gravity with the whole Masse, as it is demonstrated by *Archimedes* 5. *Proposition. Lib. 1. De Insidentibus Humido*; so that all the rest of the Masse standing out or being higher than the fluid would compose a Mountain. And that hills may be thus made, I think is confirmed by the observation of those who have sailed in the *Northern Seas*, where they see great Mountains of Ice floating upon the top of the waters, and yet there is but a very small difference between the specifick gravity of water and Ice, it being as eight to seven according to Mr. *Boyle's* observations. If then we will suppose all Mountains hollow and full of Caverns, there being a great many to our certain knowledge that are so, or else joined to some light matter, so that the whole composition may be lighter than water or the fluid Chaos; this would necessarily produce Mountains.

And now I hope the Theorist will own that the evenness and uniformity of the earth is not so necessary a consequence from its production out of a Chaos, as he at first imagined, since I have shewed him how mountains might have been form'd from his own principles of *Statics* and

and *Gravitation*. Yet I am of the opinion that there were other principles concurring to the formation of the world, besides *gravitation* and the known laws of motion, which I think it left to themselves would never produce any tolerable or habitable world.

But supposing the efficient cause of Mountains unknown or impossible to be assigned; yet still there remains the final cause to be enquired into, which will do as well for our purpose. For if I prove them to be as useful to the inhabitants of the primitive earth, as they are now to us, and that in our present state they are absolutely necessary, not only for our well being, but also for our bare subsistence; I think from thence it will demonstratively follow that they were in the primitive earth as well as in ours. And therefore the groundless assertion of the Theorist that the face of the *Antediluvian* earth was smooth regular and uniform, is as false as 'tis bold and daring.

I know there is a sort of men in this age who have excluded all final causes from the consideration of a Philosopher, as being unworthy of his enquiry, supposing his business is only to find out the true formal and efficient causes of all things, and not to concern himself with the design of nature, or the great end for which the God of Nature made any thing. But indeed these men have been so unhappy in their searches, that I dare
boldly

boldly say they have not so much as discovered the true, real and efficient cause of any one of the Phænomena which was not known and better explain'd before; tho' they have pretended to lay open the *essences* and *formal causes* of all things, and to shew the manner, how the Universe was formed from the principles of Matter and Motion.

But whatever they pretend, certain it is, that final causes are worthy of the consideration of all men, and much more of a Philosopher. By them we are led into the admiration of the wisdom of God, and discover his care and providence over the world; By them we demonstrate that the World could never be made by chance; but it must be a being of infinite wisdom that form'd it for such various uses as are to be seen in it. And therefore by all wise and considering men they are much more to be valued than efficient causes, if they could be discovered; which only tell us how the thing was perform'd, and not the use for which it was design'd. 'Tis true indeed, it is not easy to discover the use of every thing in the Universe; but from the admirable contrivance of those things, the uses of which we do know, and from the infinite wisdom of God, it may be easily concluded, that every thing in nature has its use, and is in some manner serviceable to the good of the whole.

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They who desire to see more concerning the usefulness of final causes, may consult Mr. *Boyle* of final causes, Mr. *Ray*'s wisdom of God in the works of the Creation, and some late ingenious essays upon the nature and evidence of faith by Dr. *Cockburn*.

I must confess I cannot but think it a strange and presuming boldness in the Theorist to assert, that Mountains are plac'd in no order one with another, that can either respect use or beauty: and that if they are singly consider'd they do not consist of any proportion of parts, that is referable to any design, or hath the least footsteps of art or counsel. Notwithstanding this strange assertion, I am sure, if we were without these shapeless and ill figur'd old Rocks and Mountains, as he calls them, we should soon find the want of them. It being impossible to subsist or live without them.

For setting aside the use they may have in the production of various Plants and Metals, which are usefull to mankind, and make a part of the compleat whole, and the Food which they yield to several Animals, which are design'd by Nature to live upon them; *The high Hills being a refuge for the wild Goats, and the Rocks for the Conies;* and not to mention the end they serve for in directing the Inland winds, and altering the weather, in fencing and bounding Empires and Countries, in all which without doubt they do us very
 consi-

considerable service; there is moreover one great and Universal use, which makes them absolutely necessary for the subsistence of Mankind. For without them it is certain we should have no Rivers, nor fresh currents of waters, and consequently we should want one of the greatest supports of Life. This the Learned and Ingenious Mathematician and Philosopher Mr. *Edmund Halley* has effectually proved in the *Philosophical Transactions*, where he gives us an account of the rise of Springs and Rivers from Vapours, * “ That are raised
“ copiously in the Sea, and by the winds are
“ carried over the low Land to the high
“ ridges of Mountains, where they are com-
“ pelled by the stream of the air to mount up
“ with it to the tops of the Mountains, where
“ they presently precipitate, gleeting down
“ by the crannies of the stones, and part of
“ the Vapour entring into the Caverns of
“ those Hills, the waters thereof gather as in
“ an Alembick, into the basons of stone it
“ finds; which being once filled, all the
“ overplus of water that comes thither, runs
“ over by the lowest place and breaking out
“ by the sides of the Hills, forms single
“ Springs, many of these running down by
“ the valleys or gutts between the ridges of
“ the hills, and coming to unite, form little
“ rivulets or brooks, many of these again
“ meeting in one common valley and gain-
“ ing

* *Philosophical Transactions* Number 192.

“ ing the plain ground being grown less
“ rapid become a River, and many of these
“ being united in one common channel
“ make such streames as the *Rhine*, the
“ *Rhone*, and the *Danube*, which last one
“ would hardly think the collection of waters
“ condensed out of vapours, unless we con-
“ sider how vast a tract of ground that
“ River drains, and that it is the sum of
“ all those Springs which break out upon the
“ South side of the *Carpathian* Mountains,
“ and on the *North* side of the immense
“ ridge of the *Alpes*, which is one continued
“ chain of Mountains from *Switzerland* to
“ the black Sea, so that it may almost pass
“ for a rule, that the magnitude of a River or
“ the quantity of water, which it evacuates,
“ is proportional to the length and height of
“ the ridges from whence its fountain arises.

All this I take to be undeniably evident.
For that vapours are raised by the heat of
the Sun from the Sea in such vast quantities
as will be sufficient to serve all the Rivers,
the same ingenious Mr. *Halley* has demon-
strated by Calculations. But it is also de-
monstrable that these vapours being of the
same specifick gravity with the air in which
they swim, must follow its motion, that is,
they must be carried by the winds over land
untill they meet with such an obstacle as a
hill in their way which resists their motion,
where they must precipitate and gleet down
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by its side and so form Rivers and Springs. All this is not only clear from reason, but is also confirmed by the experience of the same Mr. *Halley* while he was at *St. Helena* as he tells you, in the *Philosophical Transactions*.

And now methinks 'tis plain, that hills are so very far from being placed in the earth without any art or contrivance, that they demonstrate to us the admirable wisdom of their great maker, who has thus formed them for so necessary ends. If the earth were smooth, regular and uniform; water without doubt would stagnate and stink, for how is it possible for water to run where there is no rising ground, *no upper* land from which it is to descend to the lower and *even parts* of the earth.

I know the Theorist thinks, that he has clearly solved that great difficulty by the oval figure of his *Antediluvian* earth, in which he fancies that Rivers will run notwithstanding the earths regular and even surface. But when I come to discuss that point I will shew that the earth has not, nor ever had any such oval figure as he supposes, and upon supposition it had, yet even in that case there could be no current Water or Rivers; and where there is no current waters there must be but uncomfortable living. How many great parts of the world lie perfectly destitute of inhabitants for want of waters? Travellers tell us fearful stories of the incredible *extremities*
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they

they have suffered in going thorough the Desarts of *Arabia* for want of fresh waters.

It is plain therefore, that if the primitive earth was inhabitable there must be Mountains in it, for I think I have already proved that in a smooth regular earth there could be no Rivers. And the great advantages, which Countries reap by being well furnished with Rivers, is very evident; for without them there could be no great Towns, nor any converse with far inland Countries; since without them it is almost impossible to supply a vast multitude of People with things necessary for life. If we should suppose the *Thames* taken away from *London*, or it's course diverted so as to be at a great distance from it; there is no doubt but that City would quickly to *its loss*, very much find the want of so great an advantage; and from being one of the greatest in the space of some few hundred years, it would come to be one of the least Cities of the Universe.

It cannot be said, though Rivers are now in the present state of the world of great use and benefit to mankind, that in the *antediluvian* earth there was no such necessity for them, there being no such great traffick as now, nor such a number of people to be maintain'd by it. For this seeming objection is clearly solved by the Theorist himself in his third Chapter Book I. where he proves
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the number of the *antediluvian* people to have been at least as great as they are now, and the world altogether as well peopled. And if so, since men lived then to a very great age, (some of them to nine hundred years) they would be well taught by experience, and understand most of those things which are useful and profitable for them, as well as we do now. But I need not go about to prove there were *Antediluvian* Rivers, since it is plainly asserted by *Moses* that there were such in the second Chapter of *Genesis*, whose authority I hope the Theorist will not deny. For he himself acknowledges their existence before the Flood, and endeavours to explain their rise without the help of mountains; which *explication* in its due place I will prove to be false and impossible.

Since therefore it is plain from Reason, from Scripture, and the Theorist's own concessions, that there were Rivers in the primitive Earth, and seeing it is impossible for any such to be without Mountains, without higher and lower grounds (the Theorist's *Oval-figured* earth not being sufficient for such an effect) From thence it does evidently follow, that Mountains were before the flood. And therefore his assertion that the primitive earth was smooth, regular and uniform, is false and absurd.

C H A P. IV.

Of the Perpendicular position of the Axis of the Earth to the plane of the Ecliptick.

AMong other Characters of the Golden Age with which the Theorist *endows* his primitive Earth, one is a perpetual Spring which was then all the world over, all the parts of the years being of one and the same tenour, face, and temper. Then, says he, there was no Winter nor Summer, Seed time or Harvest, but a continual temperature of the Air and Verdure of the Earth. The reason which he brings for this assertion is, that at first the *Axis* of the Earth was parallel to the *Axis* of the *Ecliptick*, and consequently the plane of the *Æquator* being coincident with the plane of the *Ecliptick*, the Sun in its diurnal motion would seem to move always in the *Æquator*, making equal Days and Nights throughout the year.

Notwithstanding this fine description of the Theorist's, I hope to make it appear in this Chapter, that the right position of the Earth (as he calls it) is so very far from being desirable as he imagins it is, that it is one
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of the worst it could have, and that therefore the Earth was never placed by God Almighty at the beginning of the world in such a position. For I here lay it down as an *axiom* which I am confident the Theorist will allow, that God at the beginning placed the Earth in such a position as was most advantageous to the whole, and tho' perhaps another position might have been fitter for some particular place, yet the whole would have been the worse for it: God by his infinite wisdom and goodness always choosing such constitutions and positions of things as bring with them the greatest good and utility to the Universe.

Let us therefore consider whether this right position, which the Theorist says was that of the primitive Earth, was the best it could have, and if after examination we find that no such Character as that of best belonged to it, but rather the contrary, it being by far more disadvantageous to the Earth than the present one, we may confidently conclude from the above mentioned *axiom* that the Earth never had any such position.

That great and learned Astronomer *Kepler*, who certainly had more than an ordinary penetration (nay perhaps a divine impulse) in discovering the works of Nature and Providence in his *Epitome Astronomiæ Copernicæ*, has shewed that the present position of the earths *Axis* is by far preferable to any other,

especially to that of the perpendicular position to the plane of the *Ecliptick*, for he tells us in his *Lib. 3. Part 4.* That if the *Axis* of the earth about which it turned stood at right angles, with the plane of the *Ecliptick*, and the earth in the mean time turned round the Sun as it does now, that then indeed the Sun would seem to rise and set every day, and make its circuit from *West* to *East*, under the fixed stars in the space of a year, but then there would be no division of the *Ecliptick* into halves, quarters, and signs, no distinction of the year by its different qualities of heat and cold, every night would be equal to every day, there would be two places in the Earth to whose inhabitants more than half the Sun could never appear, but its Centre would continually turn round in their *Horizons*, never rising higher nor falling lower, the nearer one came to the *æquator*, so much higher would he have the Sun in his *meridian*, but in the same place it would always be at a constant height at twelve of the Clock. In the *æquator*, the Sun throughout the whole year would always be *vertical* when it comes to the *meridian*, and there only, would there be an intense and perpetual Summer, when at the *poles*, and in places near them, there would be an eternal Winter without any intermission of Frost and Snow. The Sun also would always Rise and Set in the same points of their *Horizons*, and therefore,

fore, there would be no alteration in the Earth, but upon the account of day and night, and no sort of changes in the year which would always keep the same tenour and face, the annual motion of the earth being of no use.

These are the effects which the Learned *Kepler* has shewed, would necessarily follow from the position of the Earths *axis*, which besides, that it makes the Earths Annual circuit round the Sun of no sort of use and advantage to it, (And this I suppose cannot well agree with the infinite wisdom of its Maker,) it brings with it such a train of consequences, which if men would consider, I believe there would be few so fond of changes, as to be willing to have the present oblique position altered for the perpendicular one of the Theorist, which would render this whole Island no better than a wilderness, and the greatest part of the Earth not habitable.

For under the *Æquinoctial*, to whose inhabitants, the Sun would continually at twelve of the Clock, shine perpendicularly and even throughout the *Torrid Zone*, there would be an intolerable scorching heat; In the *Frigid Zones* the cold could not be endured, and the greatest part of the two temperate *Zones* would not have a sufficient quantity of heat to ripen their fruits. All men in *England* are sensible that the heat we have in Summer, is

but just great enough to bring our Corn and Fruits to perfection, and therefore if the heat we have in Summer, were no greater than it is now about the 10th of *March*, or the 11th of *September*, the Ground would not be able to produce any *vegetables* to supply us with food, so that all of us must have changed our Climate for some more fertile Soil, which receives more of the Suns influence.

This may serve to shew how vain and false the Theorist's assertion is, that the primitive earth had its *axis* perpendicular to the plane of the *ecliptick*, and that this position is so far from being the best it could have, that it may be justly reckoned among the worse sort of positions. I come now to shew the great advantages we reap by the present position of the Earth, and how apt it is to serve the ends for which it was designed by its wise contriver.

Kepler in the above mentioned book tells us, that the earth was designed a place for those things which are liable to Generation and Corruption, and therefore it was by no means fit that the Sun should shine upon every part of it throughout the year with an equal tenour and force, but there ought to be such alterations and changes of his heat as are necessary to produce the design'd effects, for it is plain that different degrees of heat are requir'd for the production and ripening of most Plants, the heat that is requisite for
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the first growth of a vegetable, not being sufficient for the ripening and perfecting the seed thereof, and that degree of heat which is necessary for bringing the seed to perfection, would quite wither the green and tender herb.

Now all this is obtained by the present position of the Earth, and the inclination of its *Axis*, to the plane of the *Ecliptick*, for from thence arises the variety of Seasons, and different degrees of heat and cold. We perceive in the Spring time, that we have the heat of the Sun still increasing in such a measure, as the Plants require for their nutrition and growth. At last the Sun arrives at his greatest *meridian* height, and then the Plants bring forth their Seeds which grow every day more and more perfect and then are fully ripe and fit for food, and when the Sun has performed his work in our part of the World, he returns again to the tropick of *Capricorne*, to make room for the Snow and Ice which comes in the Winter for the moistening and preparing the earth for a new Crop. And tho in the *Torrid Zone*, they never have any Snow or Ice, yet at the time of the year when the Sun is *vertical* to them, there falls such a quantity of rain, as not only cools the Air, and makes the Heat of the Sun tolerable, but also fattens the ground and prepares it for the production of fruits.

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But there is one more considerable advantage which we reap by the present position of the earth which I will here insert: because I do not know that 'tis taken notice of by any. And it is, that by the present inclination of the earth *axis* to the plane of the *ecliptick*, we who live beyond forty five degrees of Latitude, have more of the Suns heat throughout the year than if the Sun shined always in the *equator*, that is, if we take the sum of the Suns actions upon us both in Summer and Winter, they are greater than its heat would be if it moved always in the *equator*, or which is the same thing, the aggregate of the Suns heat upon us while it describes any two opposite parallels, is greater than it would be if in these two days it described the *equator*, whereas in the *Torrid Zone*, and even in the temperate almost as far as forty five degrees of Latitude, the sum of the Suns heat in Summer and Winter is less than what it would be, were the *axis* of the Earth perpendicular to the plane of the *ecliptick*.

I know Dr. Bently in his last Lecture for the *Confutation of Atheism*, asserts that tho the *axis* had been perpendicular, yet take the whole year about, we should have had the same measure of heat we have now. But I am not surpris'd to find an error of this nature asserted by one who as it appears is not very well skilled in *Astronomy*; for, in the same Lecture, he confidently says, that 'tis
matter

matter of fact and experience, that the Moon alwaies shews the same Face to us, not once wheeling about her own Centre, whereas 'tis evident to any one who thinks, that the Moon shews the same face to us for this very reason, because she does turn once, in the time of her period, about her own Centre. But it were to be wished, that great Criticks would confine their Labours to their Lexicons, and not venture to guess in those parts of Learning which are capable of demonstration, for this is our present case, and I undertake to shew, that we who live in this part of the World, and have greatest need of the Suns heat, have more of it take the whole year about, than if the Sun moved continually in the equator, whereas they that live in the Torrid Zone and in places near them, and who are rather too much exposed to the heat of the Sun, than too little, have by this means less of his heat than they would have, had the earth observed a right position.

I think this consideration cannot but lead us into a transcendent admiration of the divine wisdom, which has placed the earth in such a posture, as brings with it several conveniences beyond what we can easily discover without study and application, and I make no question, but if the rest of the works of nature were well observed, we should find several advantages which accrue to us by their present constitution, which are far beyond the
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uses of them that are yet discovered, by which it will plainly appear that God hath chosen better for us than we could have done for our selves, but to return to our assertion which I design to prove by the Canon invented by that excellent Geometer Mr. Edmund Halley in the *Phil. Transf. Numb. 203. viz.* *That the Sum of the Sines of the Suns Meridian Altitudes in any two opposite parallels, being multiplied into the Sine of the semidiurnal Arch, and thereunto adding in Summer, or subtracting in Winter, the product of the length of the semidiurnal Arch, (taken according to Van Ceulen's Numbers) into the difference of the above said Sines of Meridian Altitudes: the Sum in one case, and difference in the other, shall be as the Aggregate of all the Sines of the Suns Altitude, during his appearance above the Horizon in the proposed day.* Thus that I may use Mr. Halley's own example. Let the Solstitial Heat in ☉ and ♄ be required at London, Lat. $51^{\circ} 3' 2''$.

$38^{\circ} - 2' 8''$	Co-Lat.
$23 - 30$	Decl. ☉
$61 - 58$	Sinus = ,882674
$14 - 58$	Sinus = ,258257
	Summa 1,140931
	Diff. ,624417

Diff. Ascen. $33^{\circ} - 11.$
 Arc. Semidi. æstiv. $123 - 11,$

Arc.

Arc. Semidi. byb. 56 - 49. *Sin.* '638923
Arc. æstiv. mensura 2,149955.
Arc. hyber. mensura 991683.

Then 1,140931 in ,836923 + '624417 in
 2,149955 = 2,29734 And 1,140931 in
 ,886929 — ,624417 in ,991638 = 33895 So
 that the Suns action will be as 2,29734 in the
 day of the Summer Solstice, and as 0,33895
 in the Day of the Winter Solstice.

According to this Canon I have computed
 the Heat of the Sun for every five degrees of
 its declination both *North* and *South*, at the
 Latitude of 51 degrees as in the following
 Table,

The Suns Declin.	☉ Heat in North Declination.	☉ Heat in South Declination.
0	1,25864	1,25864
5	1,47393	1,04839
10	1,692937	,845079
15	1,91489	,65091
20	2,13919	,46916
23½	2,2991	,37980

By which it will appear that the heat of the
 Sun in the Latitude of 51 degrees while it
 describes by its diurnal motion any two op-
 posite parallels, is greater than if the Sun
 these two days had described the *æquator*, as
 for

for example, the heat of the Sun in the 20th degree of *North* declination is as 2, 13919 and in the 20th degree of *South* declination as 46916 which two added together make, 2, 60135 which is more than double the number 1, 25864 which represents the heat in one *equinoctial* day, and so in all the rest of the parallels. After the same manner the action of the Sun in Summer and Winter may be easily Calculated for any Latitude or distance from the æquator, by which it will plainly appear that the heat of the Sun while it moves from *Aries* to *Libra*, that is during the time it runs through the six *Northern* signs together with its heat while it moves from *Libra* to *Aries* again, in the six *Southern* signs, is greater to us who live beyond the 45th degree of Latitude, and consequently stand most in need of the Sun's heat, than it would be had the *axis* of the earth stood at right angles with the plane of the *ecliptick*, by which the Sun would seem to move in no other circle than the *equator* as the Theorist imagines it did before the Flood.

The next thing I am to make out is that the heat of the Sun in the *Torrid Zone*, and even in the two temperate *Zones* almost as far as to the 45th degree of Latitude, is less than it would have been had the Theorist's position of the earth been the true one, and this is manifest by the following Table Calculated by Mr. *Halley* in the above mentioned *Philosophical Transactions*.

Lat.	Sun in $\gamma \cong$	Sun in $\ominus$	Sun in $\wp$
0	20000	20290	18341
10	19696	18341	15834
20	18794	21737	13166
30	17321	22651	10124
40	15221	23048	6944
50	12855	22991	3798
60	10000	22773	1075
70	6840	23543	000
80	3473	24673	000
90	0000	25055	000

Where it plainly appears, that the aggregate of the Suns heat while he is in $\ominus$ and $\wp$ and so in any other two opposite parallels, is less to those who live in the *Torrid zone*, than if the Sun by his *diurnal* motion had described continually the *equator*.

Thus we see how admirably convenient the present position of the earth is upon several accounts, and how excellently it is fitted to our use and purposes above any other that we can imagine, and therefore we can never enough admire the Divine wisdom for such an excellent contrivance, This shews us also how much we ought to regard final causes in *Natural Philosophy*, which in things of this nature

nature are by far more certain and convincing than any of the *Physical* and *Mechanical* ones which the Theorist brings to prove the truth of his assertion, which have brought him into many strange and dangerous errors, it being just that God Almighty should deliver these men up to follow strange delusions, who neglecting to proceed upon final causes the true principles of *Natural Philosophy*, and to square their notions according to the Divine Revelations contained in Holy Scripture, have followed the wild and extravagant fancies of their own imaginations.

Another Argument which may be brought to convince the Theorist that the *axis* of the earth was at first inclined to the plane of the *ecliptick* as it is now, is, that it is certain by observation that *Saturn* and *Jupiter* (whom the Theorist will allow to have suffered no Deluge as yet) have their *axis* not perpendicular but inclined to the planes of their *orbits*, and the position is true of all the other Planets as far as they can be observed, and therefore it is reasonable to suppose that the same must have been the position of the earth at the beginning, for where universally the same effect is observed, there it will be agreeable to the maxims of *Natural Philosophy*, to assign the same cause, nature being uniform and not taking different methods to perform the same thing.

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It remains now that I examin the reasons the Theorist alledges to prove that the earth before the flood had its *axis* perpendicular to the plane of the *ecliptick*; it is says he, the immediate result of gravity or libration, that a body freely left to its self should settle in such a posture as best answers to its gravitation, and this earth whereof we speak being uniform and every way equally ballanced, there is no reason why it should incline at one end more than at the other towards the Sun, as if you will suppose a Ship to stand *North* and *South* under the *equator* if it was equally built and equally ballanced it would not incline to one Pole more than to the other but keep its *axis* parallel to the *axis* of the earth, so those great Ships that sail about the Sun once in so many years whilst they are uniformly built and equally poised keep steady and even with the *axis* of their *orbits*, but if they loose that equality and the centre of their gravity change the heavier end will incline more towards the centre of their motion, and the other end will recede from it, so particularly our earth which makes one in that airy fleet when it escaped so narrowly being shipwrackt in the great Deluge, was however so broken and disordered that it lost its equal poise and thereupon the centre of its gravity changing, one Pole became more inclined towards the Sun, and the other more removed

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from it, in which skew posture it hath stood ever since.

Here the Theorist puts his false reasoning in fine words, and dresses it out in gayety according to the present mode, that it may go the smoother off, but at the same time he shews us how little he is skilled either in *Astronomy* or *Geometry*, for he tells us in one place, that the earth *stands inclined to the Sun or the Ecliptick*, but how a sphere can be inclined to a plane passing through its centre is far beyond my *Geometry* to conceive. I am sure he will find no such thing said by the Geometers or the Astronomers before him, but he may be easily pardoned for this small error, because he *meant* well, *viz.* that the *axis* of the earth was inclin'd to the plane of the *Ecliptick*, with which it makes an angle of $66^{\circ}\frac{1}{2}$. But he has committed a far greater blunder than this which is not so easily to be forgiven him, for a World-maker ought at least to understand something of *Astronomy* and of the *Copernican* system which he embraces, but it is plain that he does not know the Elements of that system, since he asserts that one Pole of the earth is more inclined to the Sun than the other, this is a position I never heard was given to the earth before. I wish he would inform us which of the two Poles is most inclined to the Sun, for I am sure *Copernicus*, *Kepler* and *Gallileo* the first
revivers

revivers of the *Pythagorean* system never said any such thing, they held that both Poles were equally removed from the plane of the *ecliptick*, the *axis* which joins them making with it an angle of $66^{\circ}\frac{1}{2}$ and keeping a position always parallel to it self and therefore whatever inclination one Pole had at any time of the year to the Sun, the opposite Pole would have the same inclination at the opposite time of the year, and therefore both Poles are equally inclined to the Sun.

'Tis true indeed that if one hemisphere were heavier than the other; the heaviest Pole would always look towards the Sun to which it gravitates, and by consequence there would be no parallelism observed in the *axis* of the earth, for if there were a Globe swimming in water, one of whose Poles were heavier than the other, it is demonstrable that the heaviest side would always be towards the centre of the earth, but since the earth does always keep its *axis* parallel to it self, and by that means makes the variety of seasons which otherwise would not happen, I think it a demonstration that the Theorist's opinion in this point is false and ridiculous. For if at the Deluge the earth had lost its equal poise, and its Centre of gravity had been altered as he will have it, the true effect of this alteration would be that the Pole which was next to the Centre of gravity had been always turned towards the Sun, and the

people living near it had enjoyed a perpetual Summer and one continued day without any night, whilst those in the opposite Pole had lived in perpetual darkness, Frost and Snow, having but one eternal Winter without any vicissitude of seasons. These therefore being the necessary consequences of such a change of gravity in the earth as the Theorist imagines, and since none of them did ever happen to it, but the earth does still keep its *axis* parallel to it self; I think it is demonstratively evident that the earth received no such *shock* by the Deluge as was sufficient to alter the Centre of its gravity, and consequently the position of its Poles in respect of the Sun.

'Tis true, a sphere put in *æquilibration*, and made turn round about a point without any other motion, necessarily keeps all its diameters parallel to themselves, and by consequence the *axis* which is one of them must also be parallel to its self, for since the time of its revolution is determined, it will perform its period in that time with the least motion possible, which is only when all the diameters of the sphere in all parts of its *orbit* are parallel to themselves as is demonstrated by the Geometers, Nature generally taking the shortest courses in all its operations, at least it takes that one and determinate method for performing its work, which the Philosophers call the *unicum in natura*, I wonder therefore why some should make a third motion for the
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the Earth, whereby it keeps its *axis* always parallel to it self, for this is rather the effect of rest than any new motion; for it is not the parallelism, but the declination of the *axis* from exact parallelism, (by which the Stars seem to move tho very slowly according to the series of the signs) which ought to be called a new motion.

But I will pass from this Subject, and consider the Theorists Argument for the right position of the Earth drawn from its *æquilibration* which he says is the immediate result and common effect of gravity or libration. For a Body says he freely left to its self in a fluid medium will settle it self in such a posture as will best answer to its gravity, and the Earth being uniformly ballanced, there is no reason why it should incline at one end more than at the other towards the Sun. This he illustrates by the similitude of a Ship equally ballanc'd, and placed *North* and *South* under the *equator*. But after all this Argument and Similitude, I can see as yet no reason why the *axis* of the Earth should be perpendicular to the plane of the *Ecliptick* more than any other of its diameters, for it is demonstrated by the writers of *Hydrostaticks*, that a sphere whose centre of Gravity is the same with its centre of Magnitude if put in a fluid of the same specifick gravity with it self, will retain any given position, and therefore there can be no reason drawn from the earths

gravity or equilibration why the position of its *axis* should be perpendicular to the plane of the *Ecliptick* rather than any other of its diameters.

C H A P. V.

Of Rivers.

THE Theorist having represented to us the first Earth as a smooth regular and uniform body without Mountains and without a Sea; In the 5th Chap. of his second book he starts a great difficulty how it was watered, from what causes, and in what manner, how could Fountains rise or Rivers flow in an Earth of that form and nature? he has shut up the Sea with thick walls on every side, and taken away all communication that could be 'twixt it and the external earth, he has removed all the Hills and Mountains where the Springs use to rise, and whence the Rivers descend to water the face of the ground, and lastly, he has left no issue for these Rivers, no Ocean to receive them, or any place to disburthen themselves into. So that his new found World is like to be a dry and barren wilderness, and so far from
being

being Paradisaical that it would scarce be Habitable.

These indeed are great difficulties, and the Theorist has acknowledged them to be such, for he says there was nothing in his whole Theory that gave so rude a stop to his thoughts as that part of it concerning the Rivers of the first Earth. But as the difficulties are great, and as one would think insuperable, so no doubt the glory that redounds to the Theorist must be nothing less, if they be clearly taken away.

To understand therefore what the state of the primitive Rivers and waters would be, he finds it necessary to consider and examine how the rains fell in the first Earth, and he tells us that the order of nature in the Regions of the air would be very different from what it is now; there could be no violent motions there, nor any thing that proceeded from extremity of cold, as Ice, Snow, or Hail, and as for Winds, they could neither be *impetuous* nor irregular in that Earth of his, seeing there were no Mountains, nor any other inequalities to obstruct the course of the vapours, nor any unequal seasons, nor unequal actions of the Sun, but as for waters, meteors, dews and rains, there could not but be plenty of these in some part or other of that Earth; for the action of the Sun in raising vapours was very strong, and very constant, and the Earth was at first moist and soft, and accord-

ing as it grew more dry, the rays of the Sun would pierce more deep into it, and reach at length the great abyfs which lay underneath and was an unexhausted storehouse of new vapours. Now the same heat which extracted these vapours so copiously, would also hinder them from condensing into rain in the warmer parts of the Earth, and there being no mountains or contrary winds or any such causes, to stop or compress them, they would take their course where they were least resisted, which is towards the Poles and the colder regions of the Earth; for *East* and *West*, they would meet with as warm an air, and vapours as much agitated as themselves, which therefore will not yield to their progress that way, but *North* and *South* they will find a more easy passage so that the concourse of vapours which were raised chiefly about the Equinoctial and middle parts of it would be towards the extreme parts or the Poles. When these vapours thus driven by the heat of the Sun were arrived in the cooler Regions near the Poles they would be condensed into rain, for wanting there the cause of their agitation, namely the heat of the Sun, their motion would soon begin to languish, and they would fall close to one another in the form of water.

Thus he thinks he has found a sufficient source for waters in the first earth, which would never fail, neither diminish nor overflow,

flow. But tho' he esteems this an inexhaustible store-house, and an easy way to furnish Waters, yet if it be narrowly examined he will find it not in the least sufficient for such an effect.

For first according to his own hypothesis there could be no Rivers for a long time after the formation of the Earth till the Sun had crackt the outward crust thereof, and its heat had reacht the great abyfs which the Theorist must needs own will require a very considerable space of time, one would think it would be several hundreds of years before the Suns heat could perform such an effect, during all which time the inhabitants of the Earth must be without waters and rivers, and lead very sad and uncomfortable lives. Is this the fruit of the Golden Age? or is this consistent with the happiness of the antediluvian Fathers? in my opinion it is directly contrary to the Scriptures, for they give us an account of rivers immediately after the formation of the Earth.

But *2dly*, I will hereafter prove that the Suns Beams did never yet reach so deep in the Earth as the thickness of the first crustation must have been, and consequently there never could arise any vapours from the abyfs to furnish the rivers.

3dly, Supposing the heat of the Sun to have crackt the crust, and to have raised vapours from the abyfs, yet it is certain it could not
do

do it in such a quantity as would be sufficient to furnish the Earth with waters. And now the Theorist will tell us, what can be more sufficient than the whole orb of water, sure this would do or else nothing could, this he will say is an inexhaustible treasure that the rivers could never drain, and therefore there was no fear of want of waters from thence. Yes there was reason to fear it very much, for supposing that there was enough in the abyss, yet perhaps the action of the Sun would not raise so much as would be sufficient to water the Earth, so there may be enough of Gold in the bowels of the earth, but if we cannot come at it we shall never be the richer for it.

That I may examine this, I will suppose the mouths of these cracks which the Sun is said to have made by its heat to be a $\frac{1}{10000}$ part of the surface of the earth, this will exceed 2600 square miles which I think is as much as the Theorist can reasonably allow them, for if it were but one continued crack round the *equator* of a miles breadth it would not exceed 2500 miles.

2dly. I will suppose with the Theorist that one half of the surface of the present earth is Land and the other is Sea, and by consequence the mouths of those pits or cracks must be one five thousandth part of the whole of the now Ocean. Now it is evident that vapours drawn by a determinate heat from
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any quantity of water in a determinate time are always proportionable to the surface of that water: for from a double surface there will be exhaled a double quantity of vapour, from a triple surface a triple quantity of vapour, and so on. Therefore the surface of the Sea being 5000 times bigger than the mouths of these cracks, there will be exhaled from it 5000 times more water than what in that case could be drawn from the abyfs. And therefore if the whole crust of the Antediluvian earth were but of the same bigness with our now dry land, it would have but one five thousandth part of the water to furnish it, that our present earth has; but because according to the Theorist, the surface of the dry land was then twice as big as it is now, there being at that time no Ocean which takes up one half of the surface: therefore it is plain that any particular Country in that case would have ten thousand times less water than it now has, there being five thousand times fewer vapours to water a double surface of Land; that is, in a Country, as big as the *Island of Britain*, there would not be so much as one River, nor so much rain in a year as does now fall in one day.

We see therefore how well the Theorist has watered his Antediluvian earth from the inexhaustible treasure of the abyfs as he calls it. For however immense that great store-house

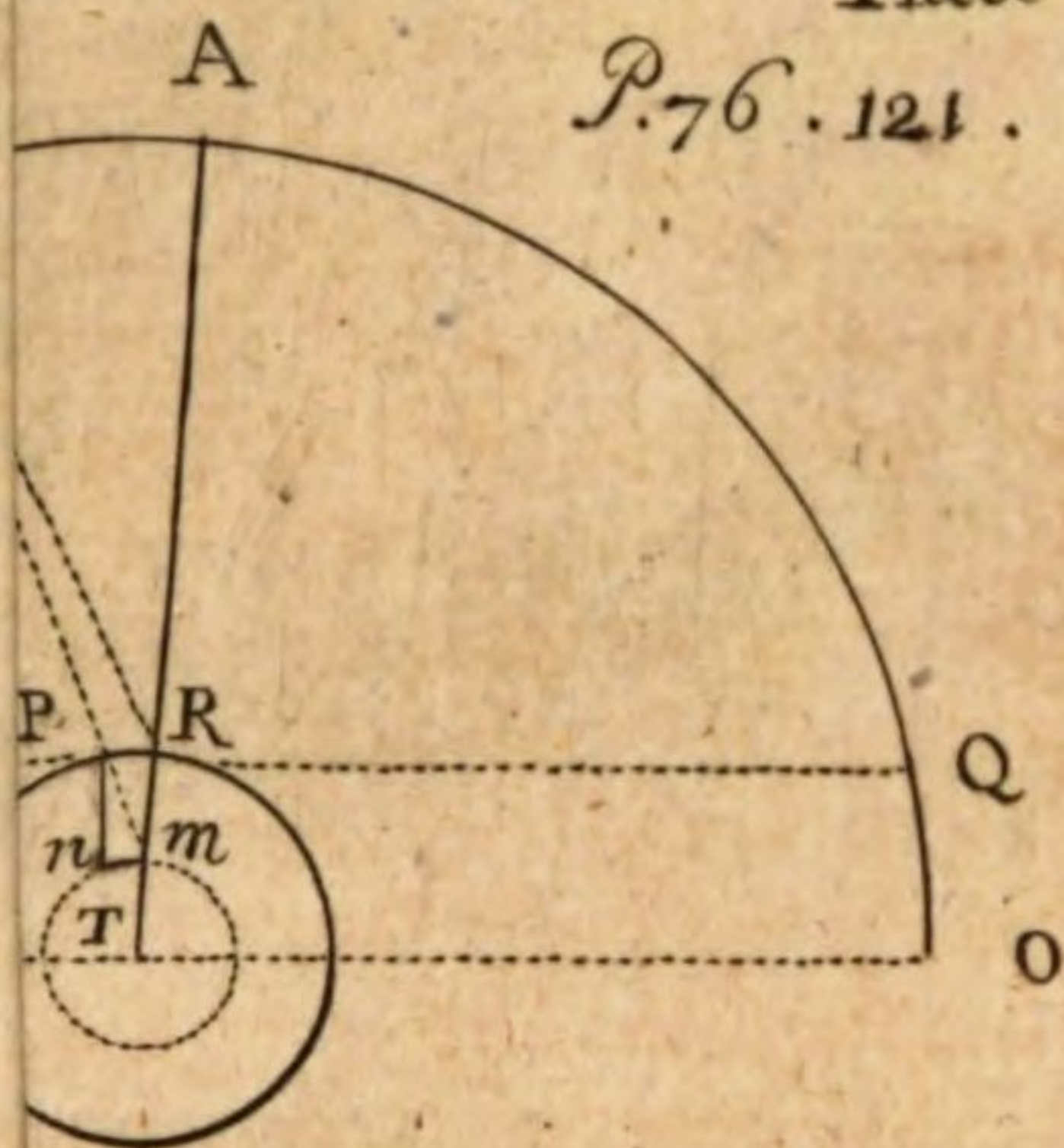
house was, yet still there would be a great scarcity of water on the surface of the earth.

Not. Except we will suppose the heat of the Sun in the primitive world considerably greater than it is in our earth, there must be less water drawn from the abyfs than what I shewed from the former Calculation, and that because the Sun could not shine so long upon the surface of the abyfs thorow the cracks as it does now upon the Sea, by reason the crust of the earth would intercept all the rays of the Sun till it came to be of a considerable height as is plain by the Figure, [*Fig. 1. Plate I.*] Where if S represent the Sun in the *equator*, and P Q the sensible Horizon, *m n* the surface of the abyfs opened by the pit P *n m* R, the Sun must be at the height H S above the Horizon before its heat can reach the surface of the waters. The heat also upon the surface *n m* would not be so great by reason of the cold orb of earth which did incircle it. And upon these and some other accounts the Sun would not raise so much water from the abyfs as it does now from the same quantity of surface in the Sea, but I will not take any advantage of these considerations leaving them to be a recompence for the greater influence of the Sun which the Theorist says it had upon the Antediluvian earth.

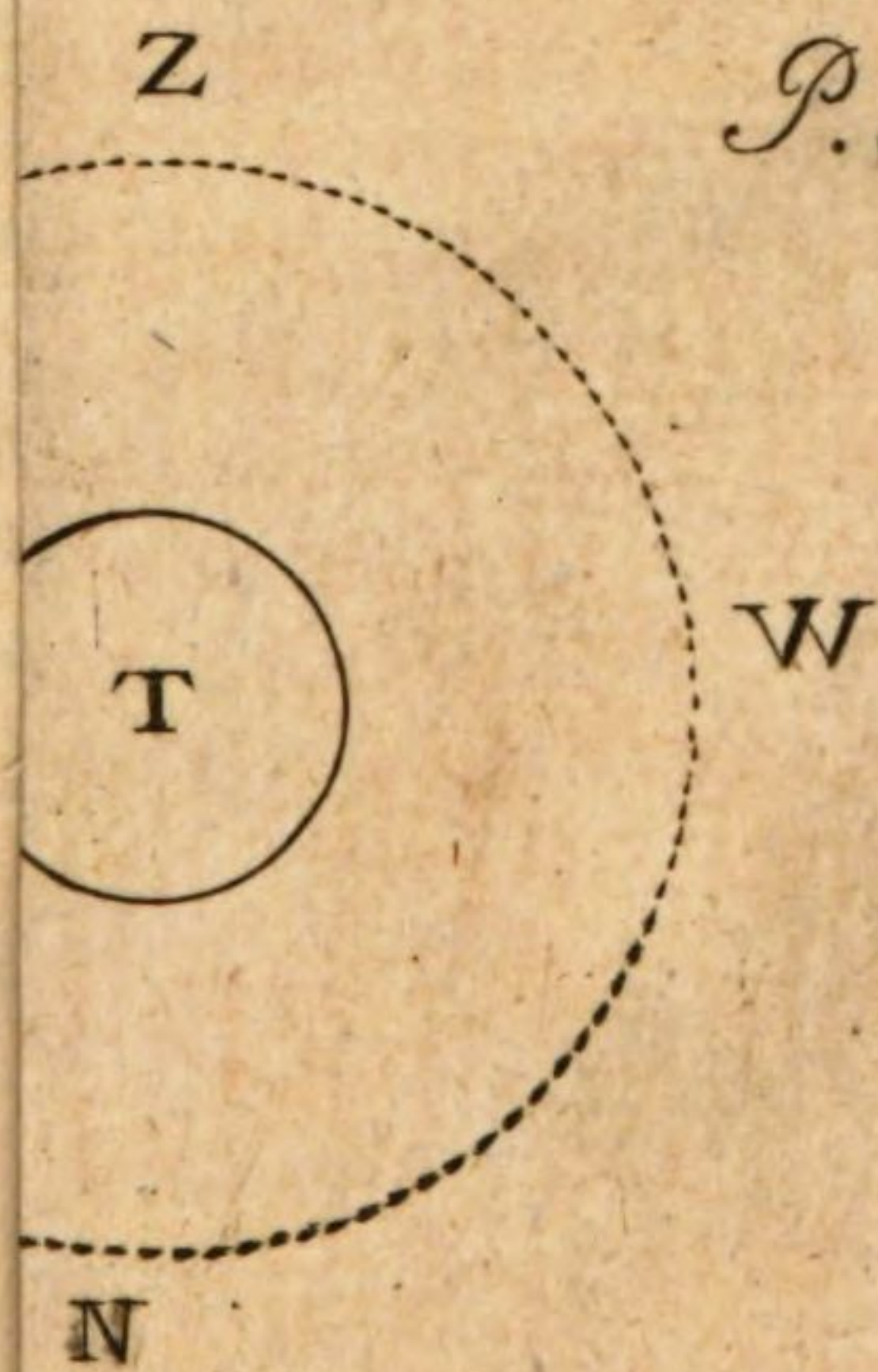
From

Plate I.

P. 76 . 121 .



P. 81 .



From hence we may fully answer an objection of the Atheists against a providence, for say they, where is the wisdom of the Creator in having so much useless Sea to no purpose and so little dry Land, for which men are every day fighting, might not the half of the Sea have been dry Land, which might have been serviceable to mankind? But this as most of their other arguments against providence proceeds from a deep ignorance of Natural Philosophy. For if there were but half the Sea that now is, there would be also but half the quantity of vapours, and consequently we could have but half so many Rivers as now there are, to supply all the dry Land we have at present and half as much more, The wise Creator therefore, did so prudently order it, that the Sea should be large enough to supply vapours for all the Land, which it would not do if it were less than it now is.

But I will suppose with the Theorist that there was a quantity of vapours exhaled by the heat of the Sun from the abyss sufficient to furnish plentifully the whole earth. Yet still there is a great doubt how Rivers could be formed: for what ways could the vapours take their course to be condensed and form Springs if there were no winds to carry them, certainly they would stagnate near the mouths of the cracks and leave the rest of the earth never a whit the better for them, and
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every one that wanted water must go as far as the *equator* to fetch it. No says the Theorist there was no need for that, the vapours being very much agitated and rarified by the heat of the Sun, and being once in the open air, their course would be that way where they found the least resistance to their motion, and that would certainly be towards the Poles and colder regions of the earth, for *East* and *West* they would meet with as warm an air, and vapours as much agitated as themselves which therefore would not yield to their progress that way: But towards *North* and *South* they would find a more easy passage, the cold of these parts attracting them as we call it, that is, making way to their motion and dilatation without much resistance, as mountains and cold places usually draw vapours from the warmer.

Here is a new use or employment the Theorist has found for the Mountains and Cold to be Gentlemen-ushers, for the vapours, and make way for their motion. He had told us before that the Cold and Hills attracted vapours, but because that word was not Philosophical, (being exploded and ridiculed by those who call themselves new Philosophers) he explains himself and tells us by attraction he meant the making way for their motion and dilatation; but how a Mountain can make way to the dilatation and motion of vapours is far beyond my pitch of understanding, to me
it

it seems reasonable that they should resist both, and hinder the vapours either from moving forward or dilating themselves. Sure I am, Cold is so far from being any ways conducive to the dilatation of vapours, that it does always condense them, as is plain by cold stone walls which always condense the vapours that fall upon them.

But the vapours says the Theorist, are very much agitated by the heat of the Sun, which gives them their motion; and therefore they would take their course towards the Poles where they find the least resistance. What other motion the heat of the Sun can give them, but upwards I cannot imagine, for by it they are raised and made specifically lighter than the air in which they swim, and therefore by a known principle in Hydrostaticks they must rise till they come to air of the same gravity with themselves, but then what should drive them to the Poles? their great agitation says he, and the little resistance they find that way, the air in the *East* and *West* being more agitated than that towards *North* and *South*, and therefore will more resist their motions.

This is a very dark answer, for I cannot conceive why the air upon the *North* or *South* side of an atome of vapour should be more agitated than that upon the *East* and *West* side, for sure I am, there is the same degree of heat on all sides of it, and therefore upon
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that account it should find an equal resistance every way. Nay the Theorist, or such an other Philosopher might with as good reason have proved, that their course would have been only *East* and *West*, for there the air was very much rarified and made thin by the heat of the Sun, the air towards *North* and *South*, not being so much rarified was thicker, and therefore would resist more, as water which is a thicker medium does more resist the motion of bodies in it than air. This seems to me to be a much better grounded opinion than the Theorists, tho' both of them are absolutely false, and may be disprov'd by the very same reasons, for how can any man fancy that vapours only driven by the heat of the Sun; would travel some thousands of miles through a fluid body of air as dense as themselves, this seems to be against the common notions of every man, and therefore I think needs no particular calculations; I cannot but believe that the Theorist did see these absurdities, since they are so very palpable, but finding no way to extricate himself from these difficulties, he was fain to make the best shift he could, which is a very bad one, and still the worse by his management.

But so far is the Theorist mistaken in this point, that supposing the great agitation of the vapours, yet it is certain that their true course would be quite contrary to what he asserts,

asserts, namely, from *East* to *West*, and not towards the *North* and *South* parts of the World, for they would be carried that way by a wind, which would continually blow from *East* to *West*. This I think I am able to prove demonstratively thus.

It is well known to all the Philosophers, that the air is a very elastick fluid body, so that being comprest with the weight of the incumbent atmosphere, it will endeavour to expand it self, and fill up a great space. If all the air therefore were equally dense or comprest, every part would equally resist anothers pressure, and from thence there could arise no motion, but if we should suppose in this atmosphere one part thinner and its tension weaker than the rest, it is certain that the circumambient air, whose force to expand it self is stronger, will rush in upon it, and keep up an equilibrium in the air. [Fig. 2. Plate I.] Now suppose E Z W N represent the Orb of Air, which surrounds the earth T, and the Sun were shining directly upon the Air at Z, which therefore by the great heat of the Sun will be very considerably more rarified and expanded than the Air at E, but afterwards the Sun shifting to the *West*, and coming to shine directly upon W, the Air at Z being rarer than the Air at E, and the heat of it being gone, its tension or force to expand it self, will not be so strong as the tension of that which is at E, and
G therefore

therefore the Air at E, will rush into Z and keep up the equilibrium, Thus also when the Sun declines to W *Westward*, the heat there being greater than it is at Z, the Air there will be rarer tho' of the same tension with the Air at Z, but afterwards the Sun moving towards N, that which is at W cooles, and being rarified its tension will grow weaker, and therefore the Air at Z, will press in upon the Air at W, and condense it till its tension becomes so strong that it is able to resist any further pressure; after the same manner will the Air move from W to N, and from N to E, that is, there will be a continual wind blowing from *East* to *West* according to the motion of the Sun; for wind is nothing but a strong stream of the Air moved according to such a direction. But this is testified by the experience of all who Sail toward the *Indies*, for they find a wind in the *Atlantick* and *Æthiopick* Oceans which continually blows from *East* to *West*.

Since therefore this is clearly agreeable both to reason and observations, there is no further doubt to be made of it. The wind therefore in the *Torrid Zone* of the primitive earth blowing continually from *East* to *West*, must of necessity carry with it all those bodies which swim in it, and are of the same density with it self; All the vapours and exhalation therefore that can be drawn either from the abyss or earth by the heat of
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the Sun, since they swim in an Air of the same density with themselves, must be carried from *East* to *West* by the motion of the winds, which is always directed that way.

And now I hope it will be plain even to the Theorist himself (tho' men are seldom convinced of the falshood of their own notions) that the vapours which are raised by the Sun under the *Torrid Zone* of the primitive earth could never have reached either of the Poles, and therefore most part of the Inhabitants of the earth must still have been without water since 'tis impossible any supplies could be brought to them from the *Æquator*.

C H A P. VI.

Of the Figure of the Earth.

TH E Theorist as he thinks having found a sufficient stock of waters for the supply of all the Rivers in the earth, does now enter upon the solution of another great difficulty, which is to shew, how in a smooth and regular earth the waters could run, and what way they would take their course after their arrival at the Poles in va-
G 2
pour;

pour; for since there were no Hills, nor Mountains, nor high Lands, in the first Earth, the vapours falling in the Frigid Zones and towards the Poles, there it seems they would stand in Lakes and Pooles, having no descent one way more than another. The Theorist therefore to take off the objection, will have the earth not to be of an exact Spherical, but an Oval figure, in which he says it is manifest that the Polar parts are higher than the *Æquinoctial*, that is more remote from the Centre as appears by his figure, and this he tells us will do the business, For by that means the vapours which fall at the extream parts of the earth will have a continual descent towards the middle parts thereof, and by consequence it will be a sufficient descent for the running of Rivers.

Now I will readily grant that the figure of the earth is not Spherical but Spheroidical, but I can see no reason why it should be an oblong Spheroid and not a broad one, for it may be of a Spheroidical figure, tho' the Axis of it were shorter than the Diameter of its equator, and if it were so, I would fain know by what means the vapours would flow from the Poles to the Equator.

But the Theorist gives us an account how the Earth came to be formed after the fashion of an oblong Spheroid. 'Tis true says he, if the Earth were as fluid a *substance* as it was in the Creation and stood immoveable without

out turning round its own Axis it would certainly settle it self into a Spherical figure, but because it turned very swiftly round its Axis, the Fluid by that agitation would endeavour to recede from its Centre of motion, and form it self into a figure very nearly Oval, as we see in the Sea, or in any Lake when the waters are driven by the wind upon the Land the Waves extend themselves in length, so in our watery Globe which is turned about its own Axis, the whole bulk of water under the equator being much more agitated than that which is towards the Poles (where the fluid in its diurnal motion describes lesser circles) it will endeavour to recede from the Centre of its motion, and because it cannot get quite off and fly away, by reason of the Air which every way presses upon it, and the straitness of its Orb in these places, neither could it flow back without a great check and resistance from the same Air, it could not otherwise free it self than by flowing towards the sides, for waters which are hindered in their motion will take the easiest course they can have. Now from this detrusion of the waters towards the side, the parts towards the Poles must come to be much increased, and those towards the equator discharged of abundance of water, which otherwise would have lain upon them, and by consequence the earth must have been of an Oblong or an Oval figure.

Now supposing all this reasoning true and solid (as indeed it is not) that the earth by its circum-rotation round its Axis, had formed it self into the figure of an Oblong Spheroid. Yet still I cannot conceive how this will help the matter, for even in that case, the waters would not flow from the Pole to the *Æquator*: Yes they will says the Theorist, since all fluids will descend as far as they can, and this is the only way of descent by which they come nearer to the Centre than by any other. 'Tis certainly true indeed that all fluids will descend continually till they meet with some obstacle which resists their motion downwards, where they must stop and go no further. And this is the reason why in our present case there could be no motion or flux of the Rivers from the Pole to the *Æquator*. For the rotation of the earth round its own Axis being still the same, the cause which thrusts the water from the *Æquator* to the Pole will also continue the same and invariable, and by consequence it will hinder the water from returning again towards the *Æquator*. And therefore supposing that the Earth were formed into an Oval figure, yet could there not be any course for Rivers; for only so far would the water ascend towards the Poles, till the force which protruded it that way came to be in an *Æquilibrium* with its gravity, and there it would stop neither ascending any further,
nor

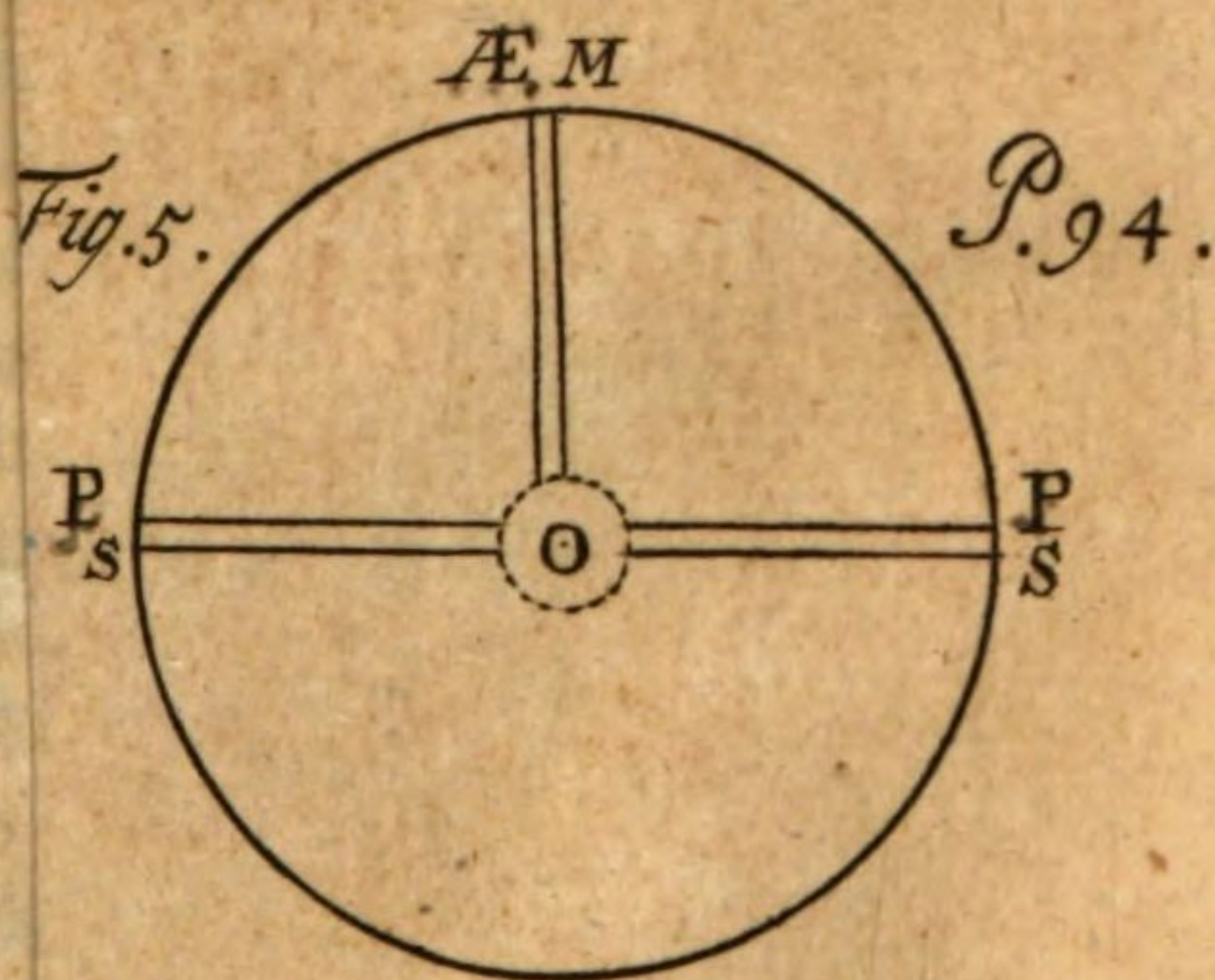
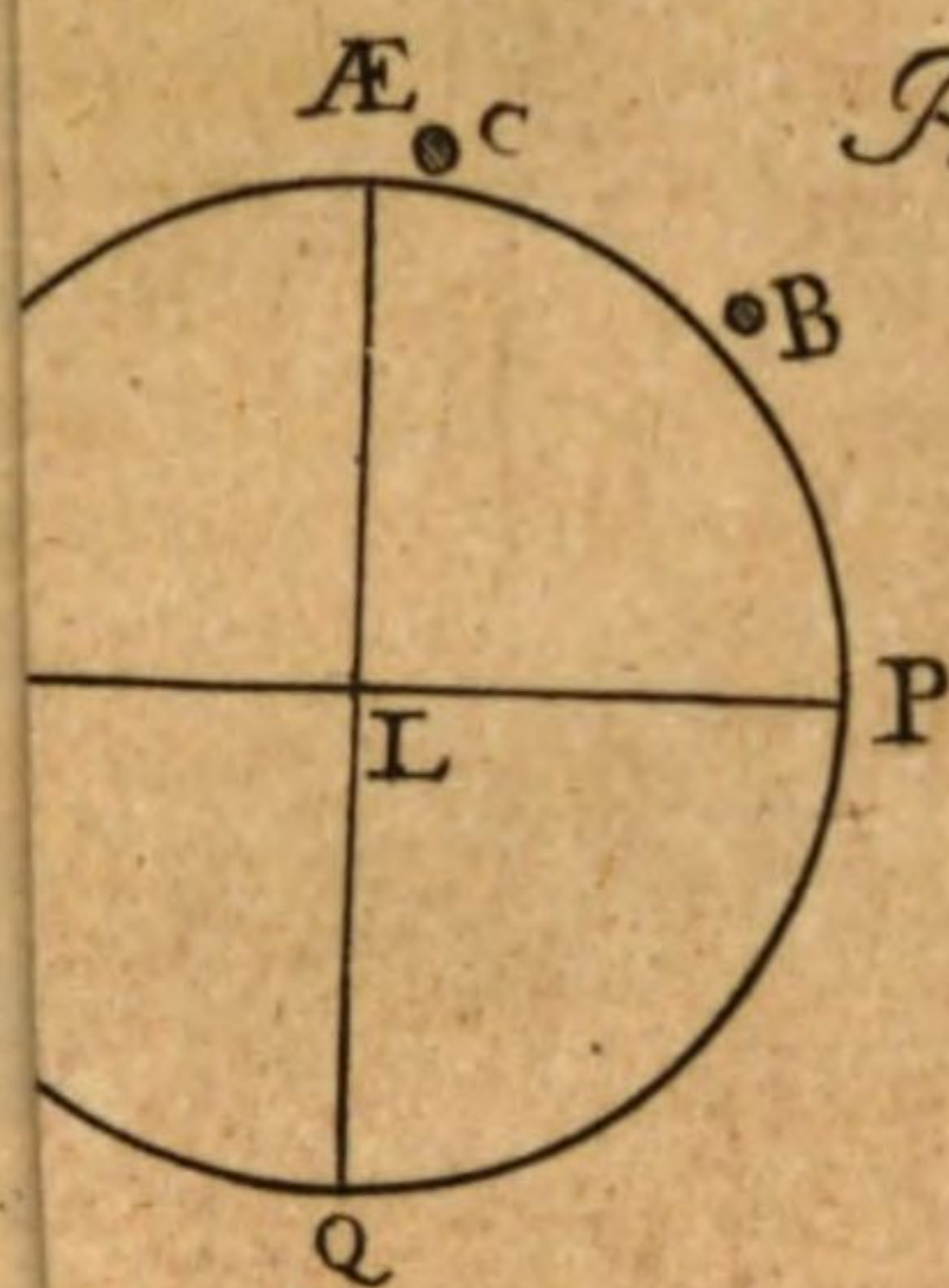
nor descending again as long as the same cause continued to act; that is, as long as the Earth turns round its own Axis in the space of twenty four hours, but if the Earth should cease to move round, then indeed in that case and no other, the water would return to the *Æquator*. For let the Figure, [Fig. 3. Plate II.] P *Æ* P Q represent the Earth, P P the two Poles, and *Æ* Q the *Æquator*, and B a Body upon the surface of the Earth, I think it is evident that the Body B will so far ascend towards the Poles, till the force which protrudes it that way be in *æquilibrium* with the force which draws it to the *æquator*: for if at B one were greater than the other, for example, the force by which it is drawn to the Poles, were greater than its gravity, or its tendency towards *Æ*, then it would still move on towards the Pole, till both forces come to act equally and there it would rest, as long as these two forces continued in *Æquilibrium* which must be so long as the Earths diurnal motion lasts. Now whatever Bodies either solid or fluid, are brought and laid upon the surface of the Earth at B, these being drawn or pusht with the same accelerating force, either to the Pole or the *Æquator*, that the first fluid had, which was constituted at B, the same causes continuing to act upon both, they will rest there also, and consequently will not descend to the *Æquator*. Thus I think I have made

it evident from the Theorists own principles, and his Oval figure of the Earth, that there could be ~~no~~ course of Rivers in the Antediluvian world, if his Theory were true, and therefore seeing there were Rivers then as well as now, for he himself has acknowledged them, and it is plainly asserted by the Scriptures that they were from the beginning, I think it is a certain demonstration that the whole account of his Antediluvian Earth is false and Chimerical.

I come now to examin the Theorists reasons by which he proves the Earth to be of an Oblong Spheroidical figure. He tells us that the fluid under the æquator being much more agitated than that which is towards the Poles which describes in its diurnal motions lesser arches, and because it cannot quite get off and fly away by reason of the Air which every way presses upon it, it could no other ways free it self than by flowing towards the sides, and consequently form the Earth into an Oval figure.

That the Reader may observe how excellent the Theorist is at drawing conclusions, I will put this reasoning in other words thus. All Bodies by reason of the Earths diurnal rotation, do endeavour to recede from the Axis of their motion; but by reason of the pressure of the Air, and the straightness of the Orb, they cannot recede from the Axis of their motion, therefore they will move towards

Plate II.
P. 87. 92.



wards the Poles where they will come nearer to the Axis of their motion, as if you would suppose a Body at the *Æquator* which doth endeavour to recede from the Axis of its motion, but because it cannot quite fly off and get away, therefore it will move towards the Poles, that is, it will come nearer to the Axis of its motion than if it had stayed at the *Æquator*. It seems to me that the Theorist in this part has endeavoured to give us a proof of his great skill in Logicks, for he from a possible supposition, has endeavoured directly to prove its contradictory, that is, because all Bodies do endeavour to recede from the Axis of their motion, therefore they will endeavour to go to the Axis of their motion. But I will now examin his Argument more particularly, and first I will grant to the Theorist, that all Bodies turned round about any Centre do endeavour to recede from it and fly off in the tangent. For this is both evident to reason and experience; but since the Air does always move round the Earth, it is plain that it will also endeavour to recede from the Centre of its motion, and by consequence, it will be no hinderance to the water to do the same, neither can it be said, that the straitness of the Orb will hinder the fluid from receding, since there is no reason to assign any such strait limits to our Globe, for our Air is not enclos'd with walls, but beyond our Atmosphere there lyes a free
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and open space: besides if there were any such straitness, without doubt it would be every where equal and the same, and by consequence, as it hindered the fluid from rising at the *Æquator*, so it would also hinder its rising at the Poles, and then there would not in that case be any Oval figure at all.

I am sure the Theorist can give no reason why he should make the Air resist the motion of the fluid upwards at the *Æquator*, and yet yield to its motion upwards at the Poles, since 'tis certain that the Air presses as much one way as another: it will by the same force hinder a fluid from rising at the Pole, by which it resisted its rising at the *Æquator*, and therefore it is plain, that the Earth could not upon any such account be of an Oblong Spheroidical figure, whose surface at the *Æquator* is nearer its Centre than its Poles are.

So far is the Theorists Opinion distant from truth in this point, that from the same very principle of a Centrifugal force it does evidently follow that the surface of the Earth towards the *Æquator* is higher or further distant from the Centre than it is at the Poles, which is directly contrary to that figure which he supposes it had in its primitive state. Now to prove this, I will suppose first, that at the beginning of the world the Earth was fluid and spherical, but afterwards God Almighty having given it a motion round its own
Axis,

Axis, all Bodies upon the Earth would describe either the *Æquator*, or Circles parallel to the *Æquator*, and by consequence all would endeavour to recede from the Centre of their motion.

It is to be here observed, that if a Body doth freely revolve in a Circle about a Centre as the Planets do about the Sun, that its centrifugal force, (or that force by which it is drawn towards the Centre) is always equal to its centrifugal force by which it doth endeavour to recede from the Centre: for the force which detains a Body in its orbit must be equal to the force, by which it endeavours to recede from its orbit and fly off in the tangent. This may be clear by the example of a Body turned round a Centre by the help of a thread which detains the Body in its orbit; the thread being stretched by the motion of the Body will endeavour to contract it self equally towards both ends by which it pull the Centre as much towards the Body as it doth the Body towards the Centre.

Now this Centrifugal force is always proportional to the periphery which each Body describes in its diurnal motion by the first Theor. of *Hugenius De vi Centrifuga*: so that under the *Æquator* which is the biggest circle the centrifugal force would be greatest, and still grow less as we approach the Pole where it quite vanisheth, there being there no diurnal

diurnal rotation. And without doubt all Bodies having this centrifugal force by which they endeavour to recede from the Centre of their motion, would fly off from the Earth if they were not kept in their orbit, by their gravity, or that force by which they are pressed towards the Centre of the Earth, which is much stronger upon our Earth than the centrifugal force; and because the gravity upon the surface of the Earth is always the same, but the centrifugal force alters and grows less the nearer we come to the Poles; it is plain that the gravity under the æquator having a greater force to oppose it than that which is near the Poles, will not act so strongly in the one place as in the other, and consequently bodies will not be so heavy under the æquator as at the Poles.

If the Circle * Æ P Q P represent the Earth, Æ Q the æquator, and P P the Poles, if C be a Body in the æquator, it is evident that it will be pulled down by two contrary forces, namely that of its gravity which pulls it towards the Centre, and that of its centrifugal force which pulls it from it. Now if both these forces were equal it is evident it would go neither of these ways; but if one were stronger than the other, it would move where the strongest force pulls it, but only with a velocity which is proportional to the differences of these two forces, and therefore it

* See Figure 3. Plate II.

it would not descend so fast as if there were no centrifugal force pulling against it. That is a Body in the *Æquator* does press less towards the Centre than at the Pole where there is no centrifugal force to lessen its gravity. Bodies therefore of the same density are not so heavy in one place as in the other.

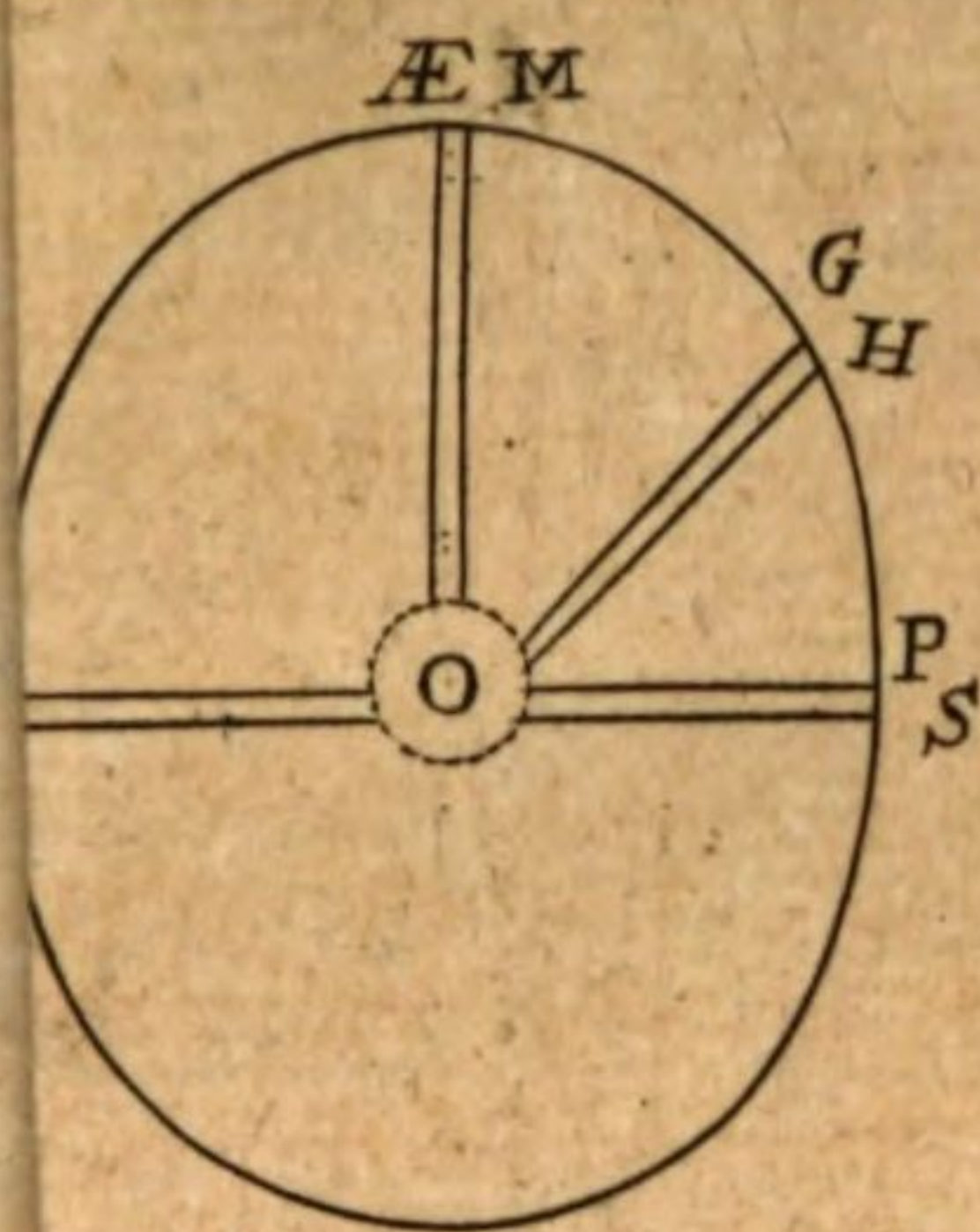
Now in a spherical fluid, all whose parts gravitate towards the Centre, I think it is evident from the principles of Hydrostaticks and fluidity, that all those Bodies which are equally distant from the Centre, must be equally prest with the weight of the incumbent fluid, and if one part come to be more pressed than another, that which is most pressed will thrust that out of its place which is least, till all the parts come to an *æquilibrium* one with another, and this is known by a common and easy experiment, if you take a recurved tube as in the figure, [*Fig. 4. Plate II.*] and fill it with water or any other fluid, it will rise equally in both Legs of the Tube, so that the surfaces *C E* and *F I* are equally pressed by the weight of the incumbent columns *B C E D*, *G F I H*, but if one of the Legs of this Tube should be filled with oil, or some other lighter fluid, and the other with water, the lighter fluid will rise higher than the other, for otherways, these surfaces which are equally distant from the Centre could not be equally pressed.

Just

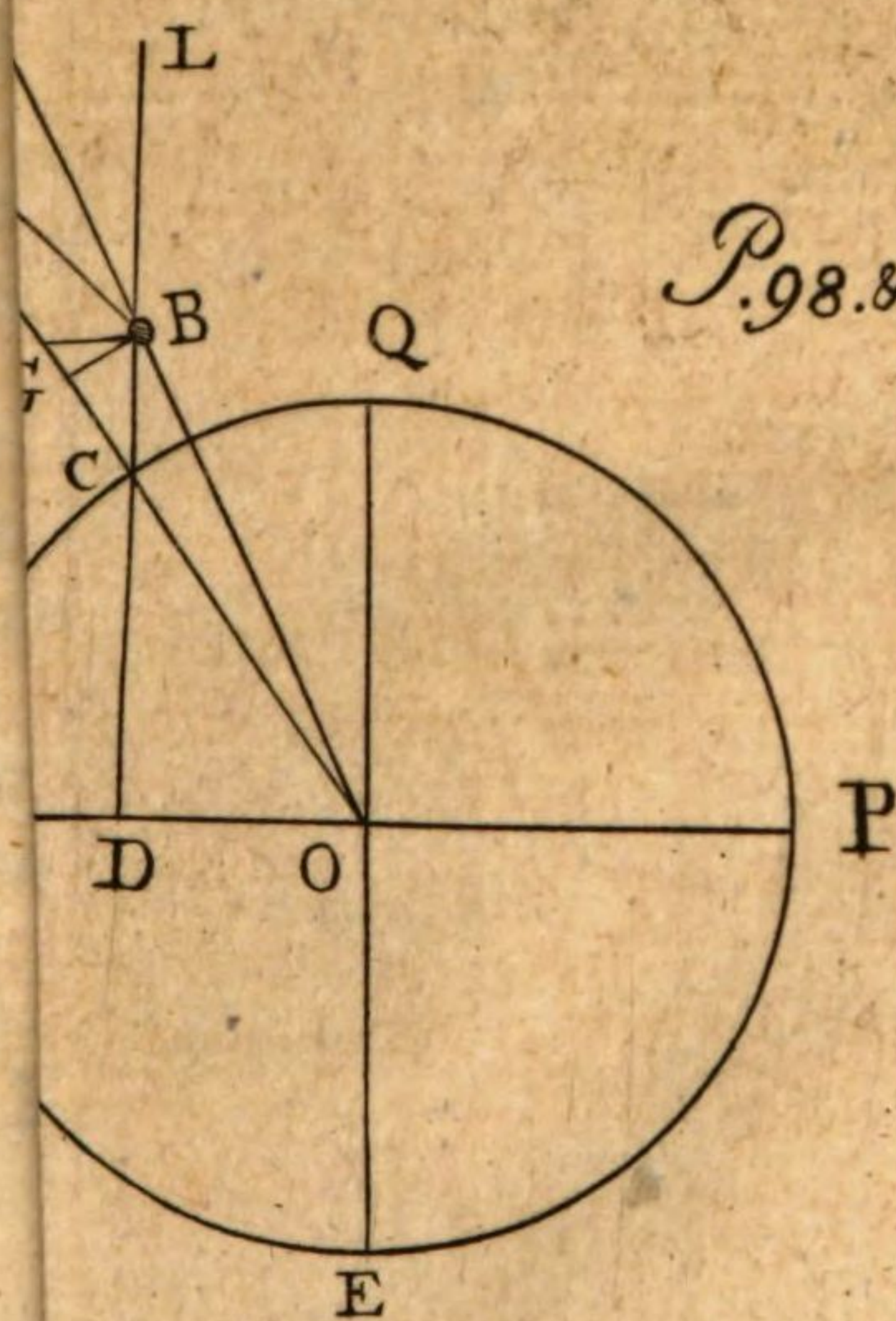
Just so, if the Figure [Fig. 5. Plate II.] P Æ M P S represent a fluid sphere, which we may imagin composed of a great many communicating Canals or Tubes, the fluid in every one of which presses upon the Centre, now if the fluid in every one of these Tubes was of equal weight or gravity, it is plain that by that means they would be also of an equal height from the Centre; for by that means only would the Centre be equally pressed by the weight of all the Tubes; but if the fluid in the canal Æ O M were lighter than the fluid in the canal P O S, it is plain that in this case the fluid P O S pressing more on the Centre than the fluid in Æ O M, the surface of the fluid in the canal Æ O M will rise to a greater height or distance from the Centre, so that by its greater height which recompenses its lesser gravitation it will press equally upon the Centre, with the fluid in the canal P O S. After the same manner * if the fluid in the canal G O H, were heavier than the fluid in the canal Æ O M, but lighter than that which is in P O S, then would the canal, G O H be shorter than Æ O M but longer than P O S, and the Figure composed of all these Tubes would be in the form of a spheroid which is generated by the circumrotation of a *semi ellipsis* round its axis, but as I have already showed that if Æ O M represent the semidia-
meter

* See Figure 6. Plate III.

Plate III.
P. 94. 95.



P. 98. &c.



meter of the *Æquator*, that all Bodies in it are lighter than in *P O S*, the Axis of the *Æquator* (we take the Diameters and Axis here not as pure Mathematical lines, but as small Canals or Tubes,) and just so those Bodies which are in the Tube *G O H*, I have proved to be lighter than those in *P O S*, but heavier than the Bodies which are in *Æ O M*, the centrifugal force in *G H*, being less than that which is in *Æ M*, and there is no centrifugal force in the Poles, *P S*. It is plain therefore that the Tube *Æ O M*, will be longer than *G O H*, and *G O H* will be longer than *P O S*, that is, the Diameter of the *Æquator* will be longer than the Axis of the Earth, and consequently the Figure of [*Fig. 6. Plate III.*] the Earth will be after the fashion of a broad spheroid which is generated by the rotation of a semi Ellipsis round its lesser Axis. This I hope will be sufficient to convince the Theorist of the falseness of his own assertion, since it is plain demonstration, that an Earth formed from a Chaos must have a very different Figure from what he supposes it had.

But I will now proceed farther and enquire, how much the gravity is diminished at the *Æquator*, or any other parallel by the centrifugal force, which all bodies acquire by being turned round the Earths Axis, that from thence we may endeavour to determine what proportion the Diameter of the Earths *Æqua-*
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tor has to its Axis, to Calculate which, I will first suppose that the mean semidiameter of the Earth is 19615800 *Paris* feet according to the late observations of the *French Mathematicians*, and since the Earth turns round its Axis in the space of 23 hours 56', for in that time the same meridian returns to the same immoveable point of the Heaven again (but the Sun in the mean time seeming to be moved a degree according to the series of the signs is the cause why there is four minutes more required, before the meridian can overtake him) from thence it follows, that a Body under the *Æquator* moves through 142688 feet in the space of one second of time. Now according to the Theorem given us by Mr. *Newton* in his *Philosophiæ Naturalis principia Mathematica Schol. prop. 4. Lib. 1.* The centrifugal force of any body, has the same proportion to the force of gravity, that the square of the arch which a body describes in a given time divided by its diameter, has to the space through which a heavy body moves in falling from a place in which it was at rest in the same time, and supposing a heavy body falls 15 foot in a second of time, by Calculation it will from thence follow, that the force of gravity has the same proportion to the centrifugal force at the *Æquator*, that 289 has to unity; and therefore by this centrifugal force which arises from the Diurnal rotation of the Earth round its axis, any body placed

placed in the *Æquator* loses $\frac{1}{289}$ part of its gravity which it would have were the Earth at rest, or which is the same thing, a heavy body placed at either of the Poles (where there is no diurnal rotation, and consequently no centrifugal force,) which weighs 289 pounds if it were brought to the *Æquator* will weigh only 288 pounds.

Having thus determined the proportion of the centrifugal force at the *Æquator* to the force of gravity, it will be easy from thence to shew their proportions in any parallel, for it is compounded of the proportion of 1 to 289, and of the co-sine of the Latitude to the Radius; for if two bodies describe different peripheries in the same time, their centrifugal forces are proportional to their peripheries or to the semi-diameters of these Peripheries, as is determined by *Monf. Hugen*s in his *Theore-mata de vi centrifuga & motu circulari*: but the Periphery which a body in the *æquator* describes has its semi-diameter equal to the radius or semi-diameter of the Earth, and in any other place the parallels in which Bodies move have the co-sines of their Latitude for their semi-diameters, and therefore it will follow that the force of gravity is to the centrifugal force in a proportion compounded of the radius to the co-sine of the Latitude and of 289 to 1. and therefore at the Latitude of 51 degrees, 46 minutes (for example) it will be as 466 to 1.

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But we must observe that it does not from thence follow, that a body in that Latitude loses $\frac{1}{486}$ part of its absolute gravity which it would have were the Earth at rest; for that could not be, unless the centrifugal force acted directly contrary to the force of gravity, which it doth no where but at the *Æquator*, for in the Figure [*Fig. 7. Plate III.*] let the circle *Q P E* represent the Earth, *Q E* the diameter of the *Æquator*, *O* its Centre, and let *B* represent a Body which we suppose to hang by the thread *A B*, and is placed any where between the Pole *P* and the *Æquator* *Q*, and let *B D* be drawn perpendicular to the axis. It is plain that if the Earth had no diurnal rotation, the Body *B* would draw the thread *A B* into the position *A C*, since by that means it descends as near as it can to the Centre, and there it would stretch the thread with all the force of its gravity; or if we will suppose that the centrifugal force acted according to the same direction *A C*, it would then directly oppose the force of gravity, and the thread would remain in the same position, but it would be stretched with a force proportional to the differences of these two forces.

But because the Body *B* turns round the Centre *D*, it will endeavour to recede from it according to the line *C B*, in which direction the centrifugal force acting, it will not directly oppose the force of gravity, but
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it will draw the thread from the position A C into the position A B, let B G be drawn perpendicular to A C. If B C represent the centrifugal force acting according to the direction B C, it is equivalent, as is commonly known, to two forces one of which is as G C, and acts according to the direction G C, which is contrary to that by which it descends to O, the other is as G B, and acts according to the direction G B, which is no way contrary to the force of gravity, If therefore B C represent the total centrifugal force of the Body B, that part of it which directly opposes the force of gravity will be as G C: from whence it follows, that the decrease of gravity in going from the Pole to the *Æquator* is always as the square of the co-sine of the Latitude: for draw B H parallel to the Axis P P, and because the triangles H C B, C D O are æquiangular, therefore H C is to C B as C O is to C D, or as Q O is to C D, but Q O is to C D as the decrease of gravity at Q is to the centrifugal force at C, and therefore H C is to C B as the decrease of gravity at Q is to the centrifugal force at C. But if C B represent the centrifugal force at C, G C will represent that part of it which acts directly against the force of gravity, and consequently the decrease of gravity at the *Æquator* is to the decrease of gravity at C as H C is to G C: now H C is to G C in duplicate proportion

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of HC to CB , or of CO , or OQ to CD , by the 8th of the 6th of *Euclid*; and therefore the decrease of gravity at Q is to the decrease of gravity at C , as the square of CO is to the square of CD which was to be demonstrated.

From whence it is plain that if HC represent the decrease of gravity at the *Æquator*, and GC its decrease at C , then will GH represent the difference of these two diminutions, or the difference between the gravity at Q and the gravity at C , but HC is to HG in duplicate proportion of HC to HB , or of OC to DO , that is, the decrease of gravity at the *Æquator* is to its increase at C , as the square of the radius is to the square of the sine of the Latitude.

By this also it will appear that the direction of heavy Bodies is not to the Centre of the Earth, as has been always supposed, For if we take a heavy Body and hang it by a thread, the thread produced will not pass through the Centre any where but at the Poles and the *Æquator*, for in the Figure the thread is carried by the centrifugal force of the Body B from the position AC , into the position AB where it will rest.

Now to determine the angle CAB which the line of direction of the Body makes with the line AC , let AN be drawn parallel to BC , and produce OB till it meet with it in N , and let us consider the Body B as drawn
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by three powers according to three different directions BO BL and AB , the power which pulls it according to BO is its gravity, that which draws it according to the direction BL is its centrifugal force, and that which acts according to AB is the strength of the thread, by which the Body is hindered to move according to either of the other two directions, and therefore it is an æquilibrium with the other two powers, but by a Theorem which is demonstrated by several of the writers of Mechanics, but particularly by *Monf. Hugen* in his small Treatise *De potentiis per fila trahentibus*. If a Body be pulled by three different powers which are in æquilibrium with one another, according to three different directions AB , BK , and BO , these three powers will be as the three sides of the Triangle ABN , viz. as AB , AN , and BN respectively; or as AB , BC and $AC:BN$ being very near parallel, and consequently equal to AC , since they do not meet but at a great distance. From hence it follows that the force of gravity is to the centrifugal force as, AC is to BC : but a method has been already shown how the proportion of the force of gravity to the centrifugal force may be determined, and therefore the proportion of AC to BC , may be also determined, which at the Latitude of $51^{\circ}, 46''$, is as 446 to 1. Therefore in the Triangle ABC , the proportion of AC to BC is known and the angle ACB

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being equal to the angle COQ which is subtended by the arch CQ the Latitude of the place, from thence by the Tables of Sines and Tangents the angle BAC may be known, which in the above mentioned Latitude is about five minutes.

From hence also it will appear that it is not the line AC , which being produced passes through the Centre, but the line AB that is perpendicular to the curve PQ , for all the particles of the fluid will settle themselves in such a position that their lines of direction downwards must be perpendicular to the surface of the Body which they compose, for otherwise the parts of the fluid would not be in an *Æquilibrium* one with another, and therefore altho' the lines of direction of heavy Bodies do not pass through the Centre of the Earth, yet are they still perpendicular to their Horizons, and upon this account there could arise no error in levelling of lines, and in finding the risings and fallings of the ground.

Upon this account also it will appear that the surface of the Earth is not spherical, for if it were, then would all lines drawn from the Centre be perpendicular to the surface of the Earth, since it is the known property of a sphere that they must be so, but I have already shewed that it is not so in the Earth, and therefore it is plain that the Earth is not a Sphere. That therefore I may enquire more particularly

particularly into the Figure of the Earth, I will resume my former hypothesis, that the Earth is composed of an infinite number of Canals which communicate with one another at the Centre and are all equiponderant, of which we will consider two as OQ and OC , and let OQ be $= r$, $OD = x$ and $DC = y$, let the absolute gravity be called p , and the centrifugal force at the $\text{\AA}equator$ n , OC is equal to $\sqrt{x^2 + y^2}$, the weight of the Canal OQ is equal to the absolute gravity of the whole canal, *minus* the centrifugal force of each particle contained in it, and because the centrifugal force of each particle is as its distance from the Centre, and therefore it increases in an Arithmetical progression, the greatest of which is n , consequently the sum of all the centrifugal force is $= \frac{1}{2} nr$, but upon the hypothesis, that gravity is the same at all distances from the Centre, the absolute gravity of the canal OQ is pr , and therefore its real weight upon the Centre OQ is $pr - \frac{1}{2} nr$. After the same manner the absolute gravity of the canal OC is $p \times \sqrt{x^2 + y^2}$ but the sum of the centrifugal forces of all the fluid in the canal OC is equal to the centrifugal force of the fluid in CD (as may be easily proved from the consideration of inclined Planes) But the centrifugal force at C being to the centrifugal force at Q as CD is to OQ (that is, as y is to r) the centrifugal force at C will be equal

to $\frac{ny}{r}$ and because the centrifugal force of each Particle is as its distance from the point D which is the Centre of the Circle, that the fluid in the canal CD describes, and therefore the centrifugal forces in counting from the point D must increase in an Arithmetical progression, the greatest of which is $\frac{ny}{r}$ and therefore the summ of all the centrifugal forces in CD must be equal to $\frac{nyy}{2r}$ therefore the weight of the canal OC is $= p\sqrt{x^2 + y^2}$ $-\frac{1}{2}\frac{nyy}{r} = pr - \frac{1}{2}nr$ which equation expresses the nature of the curve that is made by the section of the earth with a plane through its poles, and by this, the proportion of the axis of the earth to the diameter of the æquator may be easily determined; for when CO coincides with OP, then CD or y becomes equal to nothing, and the equation is $p\sqrt{x^2} = pr - \frac{1}{2}nr$ or $px = pr - \frac{1}{2}nr$, and therefore by the 16th of the 6th p has the same proportion to $p - \frac{1}{2}n$ that r has to x or OQ to OD, but p is to $p - \frac{1}{2}n$ as 289 is to 288½ or as 578 to 577 which therefore is the proportion of the greatest diameter of the Earth to its least; but this is upon supposition that

that gravity is the same at all distances from the Centre, but if we will suppose that the gravity of bodies without the Earth is in a proportion reciprocal to the squares of their distances from the Centre, the gravity of those bodies which are within the Earth will be directly as their distance, both which do best agree with the observ'd Phænomena of nature; then will the gravity at the *Æquator* be to the gravity at the Poles as 689 to 692, which numbers in this Hypothesis do also express the proportion of the Diameter of the Earth drawn through its Poles to its Diameter drawn in the plane of the *Æquator*.

It is upon the account of this diminution of gravity, according as we approach the *Æquator*, that pendulums of the same length in different Latitudes, take different times, to perform their vibrations; for because the accelerating force of gravity is less at the *Æquator* than under any parallel, and under any parallel it is still less than under another which is nearer the Poles, it do's plainly from thence follow that a body plac'd in the *Æquator*, or in any parallel will take a longer time to descend through an arch of a given circle, than it would do at the Poles, and the farther a body is removed from the Poles, the longer time it will take to descend through any given space.

From hence it follows that the length of pendulums which perform their vibrations in
equal

equal times in different Latitudes are directly as the accelerating forces of their gravities. For the time a Body takes to descend through an Arch of a Cycloid, is to the time it will take to fall through the Axis of the Cycloid always in a given proportion, viz. as the Semiperiphery of a circle is to its Diameter by the 25th Prop. of *Hugens Horologium Oscillatorium*; and therefore when the times in which a body descends through the Axis of two different Cycloids are equal, the times of the descent through the Cycloids will be also equal, but when the times of the descent through the Axes are equal, these Axes, and consequently the lengths of the pendulum which vibrates in these Cycloids are proportional to the accelerating forces of their gravities.

By this, if we know the length of a pendulum which performs its vibrations in a given time, in any one part of the Earth, it is easy to determine the length of a pendulum which performs its vibrations in the same time, in any other part of the Earth, as for example: the length of a pendulum which vibrates seconds at *Paris* is three foot eight lines and an half, let it be required to find the length of a pendulum which vibrates seconds at the Equator. Because the gravity at the Pole is to the gravity at the *Æquator* as 692 is to 689, therefore the decrease of gravity at the *Æquator* is $\frac{3}{692}$ parts of the whole

whole gravity: but as I have before demonstrated the decrease of gravity at the *Æquator* is to its increase in any other Latitude, as the square of the radius is to the square of the sine of the Latitude; now the Latitude of *Paris* being $48^{\circ}. 45'$ its sine is 75. 183, and therefore the square of the Radius is to the square of the sine of the Latitude as 1000000 to 565248, but as 1000000 is to 565248, so is 3.000 the number which represents the decrease of gravity at the *Æquator* to 1. 695, the number which represents its increase at *Paris* which added to 689 the gravity at the *Æquator* makes 690. 695 the number which will represent the gravity at *Paris*. But I have already shewed, that as the gravity at *Paris* is to the gravity at the *Æquator*, so is the length of a pendulum which vibrates seconds at *Paris* to the length of a pendulum which vibrates seconds at the *Æquator*, that is as 690, 695 to 689, so is 36, 708 the length of a pendulum at *Paris* which performs its vibration in a second to 36, 616, which therefore is the length of a pendulum which performs its vibrations in a second at the *Æquator*: so that the difference between these two pendulums is $\frac{92}{1000}$ parts of an inch which comes pretty near the observations of *Mons. Richer*, who at the Island of *Cayen*, whose Latitude is 5 degrees, found that a pendulum which vibrates seconds there, was a tenth part

part of an inch shorter than a pendulum which vibrates seconds at *Paris*.

Thus we see that the principles and hypothesis and withal their consequences upon which the broad Spheroidical Figure of the Earth is founded do exactly agree with observations, and therefore there is no doubt to be made but that the Earth is really of such a Figure, and that the hypothesis upon which this Figure is grounded (*viz.* the diurnal rotation of the Earth and by consequence the centrifugal force of all Bodies upon it) must be admitted for a true one; since the different vibrations of Pendulums of the same length in different Latitudes can depend upon no other cause: for the change of Air is not able to produce any such effect, for if the Air made really any alterations in the vibrations of a Pendulum it would produce a quite contrary effect, than what is observed; for Pendulums near the *Æquator* would move faster than they would do in places of greater Latitude; the Air in the one place being more rarified is much thinner and finer than it is in the other, and therefore gives less resistance to Bodies which move in it.

In this reasoning we have supposed the Earth to have been at first fluid as the Theorist has done before us, but if we will put the case that the Earth was at first partly fluid and partly dry as it is at present, yet because
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we find that the land is very near of the same Figure with the Sea (only raised a little higher that it might not be overflowed) composing with it the same solid, and I have already shewed that the Surface of the Ocean is spheroidical and not spherical, there is no doubt to be made but that the Land was formed into the same Figure by its wise Creator, at the beginning of the World, for if it were otherwise, then would the Land towards the *Æquator* have been overflowed with water, which as I have already proved, must have been higher at the *Æquator* than at the Poles; and therefore the Sea would rise there and spread it self like an inundation upon all the Land.

But for a further confirmation of the spheroidical Figure of the Earth let us consider some of the other Planets especially *Jupiter* who turns round his own Axis in the space of ten hours: It may easily be observed that his Axis is considerably shorter than the Diameter of his *Æquator*, and that in the proportion of seven to eight, as the observations of Mr. *Flamsteed* and Mons. *Casini* do testify; and therefore we need not doubt but that the Earth which is a Planet like the rest and turns round its Axis as they do, is of the same Figure.

But the Theorist in his Latin Edition of the Theory, as also in his Answer to Mr. *Warren*, seems to insinuate, that the only way to find
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the true Figure of the Earth is by measuring of it, and by that means to find what proportion the degrees of the Meridian in different Latitudes have to one another; for if they were exactly equal one to another, and also equal to the degrees of Longitude counted upon the *Æquator*, then without doubt the Figure of the Earth would be Spherical, but if otherwise Spheroidical.

Now tho' I have already determined the Earths Figure from other Principles; Yet to comply with the Theorist in this point, I will give him an account of a Book whose extract I have seen in the *Acta Eruditorum Lipsiæ publicata* for the year 1691, written by one *Job. Casp Eifenschmidt* a German who calls himself Doctor of Philosophy and Physick. The Title of the Book is, *Diatribæ de Figura Telluris Elliptico-Sphæroide*. And it is Printed at *Strasburg* in the Year 1691. The Learned and deep-thinking Author of this Book after he has Answered, at least has endeavoured to Answer the Arguments of *Archimedes* and others, by which the Figure of the Earth was proved to be Spherical, doth embrace the Opinion of the Theorist, and asserts that its Poles are higher or further distant from the Centre than its *Æquator*: To prove this, he sets down an account of the different magnitudes of degrees of the Meridian according to the observations made of them in different Latitudes, and comparing them one with another,

another, he found that they continually decreased as the Latitudes increased, and indeed, as he says in the same proportion, as appears by the following Table, which I have inserted from the above named Extract.

Observers.	The Latitude of the Places observed.	The Magnitude of a Degree in Roman Miles.
<i>Eratosthenes.</i>	27°	100
<i>Ricciolus.</i>	44½°	80
<i>Mons. Piccard.</i>	49°	74
<i>Fernellius.</i>	49½°	73½
<i>Snellius.</i>	52°	71⅓

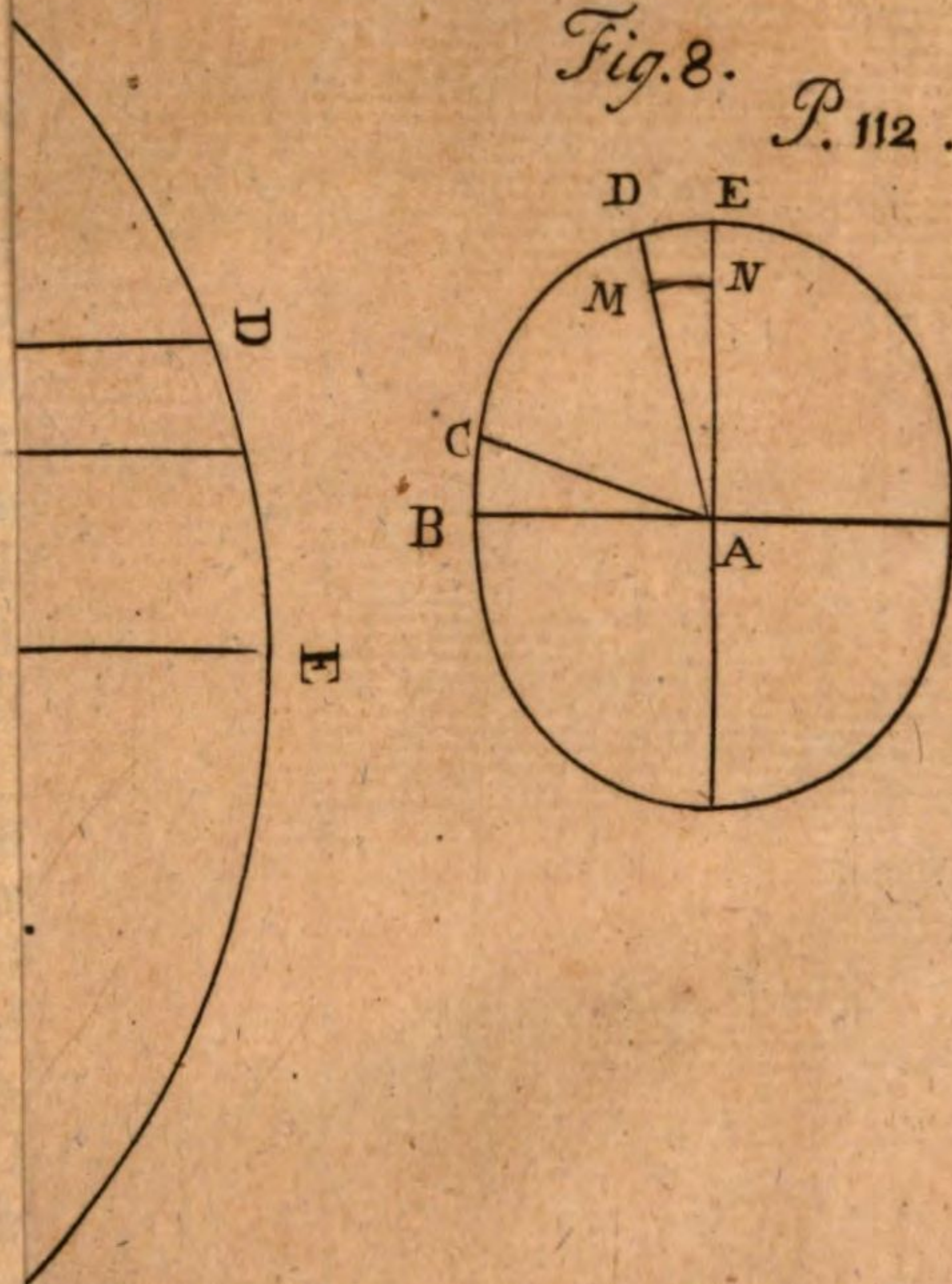
From this he concludes that a plane cutting the Earth along its Axis would not be a Circle but an Ellipsis, whose longer Axis would pass through the Poles and coincide with the Axis of the Earth; but its lesser Axis would be the common Section of the *Æquator* with the Ellipsis, and from thence he infers, that the Earth is not of a Spherical, but an oblong Spheroidical Figure. After that he disputes against Mr. *Newtons* Hypothesis, which makes the Earth of a direct contrary Figure, and thinks that the accurate Observations by him related, are by far to be preferred to the Hypothesis upon which Mr. *Newtons* Calculus is grounded.

None

None but a man of prodigious stupidity and carelesness could reason at this rate! If he had asserted that the Earth was of an Oval Figure because Grass grows or Houses stand upon it, it had been something excusable; for that Argument tho' it did not infer the conclusion, yet it could never have proved the contradictory to be true. But to bring an Argument which does evidently prove that the Earth has a Figure directly contrary to that which he would prove it has, is an intolerable and an unpardonable blunder; for if he had but protracted the Figure, and drawn equal Angles from the Centre, he might have easily perceived, that the Angle whose Crura were longest, would have the greatest Subtense. Thus if the Angles [Fig. 8. Plate IV.] DAE and BAC were equal, but AD were longer than AB, it is evident that the subtense DE would be longer than the Subtense BC, for if you take AM and AN equal to AB and AC and draw the Line MN, the Angles being small, BC and DE will differ very little from streight Lines, but BC is equal to MN, which is plainly less than DE, and therefore it is evident that BC is less than DE, that is, where the Subtenses or the degrees are greatest, there also is the greatest Diameter: but it is plain by the Observations which Mr. *Eisenschmidt* relates, that the degrees are biggest at the *Æquator*, therefore the greatest Diameter of the

Plate IV.

Fig. 8. P. 112.



the Spheroid must be that of the *Æquator*, and not the Axis of the Earth.

So far is this Argument drawn from Observations from destroying Mr. *Newtons* Hypothesis, that it would most evidently confirm it, if the Observations were exact enough, which I believe they are not.

I cannot but wonder at the strange Logicks of our Modern Philosophers who are able to draw any conclusion they have a mind for, from any Principles that can be given them. No man that looks narrowly into their Books can want Instances in this matter, But in case this is not so well observed, I have furnished the Reader with two examples of this sort. The one is the Theorists way by which he proves the Earth to be of an Oblong or Oval Figure from the Principles of a Centrifugal force which all Bodies have that are on it. Now I think I have plainly shown that the true Conclusion he ought to have inferred from this Hypothesis is, that the Earth had a quite contrary Figure from what he fancied it had. But Mr. *Eisenchmidt* has given us a yet plainer proof of this thing, for because he found that the Degrees of Latitude near the *æquator* were bigger than those which were near the Pole, he very innocently concludes that the Earth had its Axis longer than the Diameter of its *Æquator*; but if he had understood the first six Elements of *Euclid*, or indeed those of common sense he might easily
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have demonstrated the contrary: it is strange that when there is but one Right and one Wrong Opinion in this Point, that he should be so unlucky as to hit upon the false one to maintain it.

C H A P. VII.

Of the Dissolution of the Primitive Earth.

HITHERTO I have refuted the Theorists Motion, Position, and Figure, of the Primitive Earth. I am now to consider his method of Dissolving the Fabrick he has raised, and to Examin how and by what causes, the first Earth which had all the Beauty of Youth and Blooming Nature, Fresh and Fruitful, and not a Wrinkle or Scar on all its Body, came to be dissolved; how the Fabrick was broke, and the Frame of the whole torn in pieces, how it came to be a shattered and confused heap of Bodies, as we now see it, placed in no order one to another, nor with any correspondency or regularity of parts, as the Theorist represents it to be.

He tells us that one would soon imagin that such a structure as that of the first Earth was,

was, would not be perpetual nor last many thousands of years, if one consider the effect, the heat of the Sun would have upon it, and the Waters under it, drying and parching the one, and rarifying the other into vapours: For according to him, the course of the Sun was such at that time, that there was no diversity or alteration of Seasons in the year, as there is now; by reason of which alteration of Seasons, our Earth is kept in an equality of temper, the contrary Seasons ballancing one another; so that what moisture the heat of the Summer sucks out of the Earth, is repaired again in Rains the next Winter, and what chaps are made in it are filled up, and the Earth is reduced to its former constitution. But if we should imagin a continual Summer the Earth would proceed in dryness still more and more, and the cracks would be wider and pierce deeper into the substance of it. The heat of the Sun therefore according to the Theorist, acting continually upon the Earth, would have reduced it in the space of some hundreds of years to a considerable degree of dryness, in certain parts, and would also have much rarified and exhaled the water under it; so that considering the structure of that Globe, the exterior Crust, and the Water under it, he thinks it may be fitly compared to an *Æolipile* or an hollow Sphere, with Water in it, which the heat of the fire rarifies and turns into Vapour

or Wind ; the Sun here is the Fire, and the exterior Earth the shell of the *Æolipile*, and the Abyfs the water within it ; as soon then as the heat of the Sun had reached the waters in the Abyfs it began to rarify them, and raise them into Vapours, by which rarification they required more room, than they did before, and finding themselves pent in by the exterior earth they pressed with violence against that Arch to make it yield and give way to their dilatation: and by this means the Earth was broken, and the frame of it torn in pieces as by an Earthquake, and those great portions or fragments into which it was divided, fell down into the Abyfs, some in one posture and some in another, and was the cause of a general Deluge. I shall now examin these causes which the Theorist has given for the Dissolution of the Earth, and in this Chapter I will first enquire whether the heat of the Sun can reach so far as the great Abyfs to rarify the waters thereof.

First then I have proved in the third Chapter of this examination, that there were Hills and Mountains in the primitive Earth as there are now in ours. I have also shown that the Axis of the earth was then enclined the same way to the Plane of the Ecliptick as it is at present; from thence it plainly follows that there was then, the same variety of Seasons and Alterations of Heat and Cold in the primitive earth, that there are now in
our

our earth, and by consequence, all the Arguments drawn from the great heat and strong action of the Sun upon the Antediluvian earth must fall to the ground, there being then no greater heat of the Sun on the earth than there is at present.

But 2^{dly}, there are places in the earth, as the Island of *Barbadoes* and some other Islands near the *Æquator*, where there is little or no variety of Seasons or alteration of the Sun's heat, but it continues to shine very strongly upon them throughout the whole year, and yet in none of them is there any of these great Chaps and Cracks which the Theorist says were made in the primitive earth by the strong action of the Sun; tho' it has shon above thrice as long upon these Islands as it did upon the Antediluvian World.

3^{dly}, It is certain that if we judge according to experience that the heat of the Sun doth not reach far into the Earth, and that its beams can go but a very little way into the Crust; for in Vaults and Caves there is no sensible alteration of heat in Summer and Winter, even tho' they have a communication with the open Air, And in the deep pits of the Royal Observatory at *Paris* it has been found by experience, that a Thermometer placed there, in the coldest day of Winter does not sensibly vary from what it was in the greatest heat in Summer; and they who work in Mines can tell how little difference

they observe of heat in the Summer, more than in the Winter, in places underground. But if the heat of the Sun could penetrate for any considerable depth the Crust of the Earth, it is plain, that when its heat is strongest and most intense upon the Surface, it would also be most intense within the Crust; but the fore-mentioned experiments do prove that within the bowels of the Earth there is no sensible difference between the heat of the Sun when its action is strongest, from what it is when its action is weakest. Since then the heat of the Sun does not penetrate the Earth so as to be sensible even for the small space that we are able to dig thorough, how can we imagin it possible that it should ever reach the Abyss through the whole exterior Crust of the Earth so as to be able to heat the water and raise it into Vapour?

But that I may bring this point to a Calculation as near as I can, I will suppose that the heat caused by the direct influence of the Sun upon any Surface is always (all other things being the same) as the quantity of Rays of heat which falls upon that Surface; which I believe the Theorist will allow: I will also suppose that fewer Rays of heat passed thorough the solid Orb than if it had been composed of several concentrical Surfaces placed at some distance from one another, every one of which transmitted only the one half of the Rays of heat which fell upon it: this I think may be also easily allowed; for
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it is plain, that the Surface of the Earth does not transmit the half, nay not the hundredth part of the Suns beams which fall upon it. These things being supposed, it is plain that but one half of the Rays which fall upon the first Surface, would fall upon the second, but one fourth of them upon the third, one eighth part of them upon the fourth, and one sixteenth part upon the fifth, &c. so that they would still decrease in a Geometrical proportion of 2 to 1; and if there were but one hundred of these Surfaces, the number of Rays which fell upon the first would be to the number of Rays which passed thorough to the last as 2^{99} to 1, or as the ninety ninth power of 2 is to 1. How great a disproportion then would there be between the number of those Rays which fell upon the first surface and those which fell upon the last? for the ninety ninth power of 2 is a number which if written at length would consist of a hundred Figures: but if we should imagin all the spaces between the Surfaces filled up with solid and not diaphanous matter as it really is so in the Crust of the Earth, the heat upon the surface must be much less than what it would be by the former proportion.

From thence we may conclude that if the heat of the Sun upon the Surface of the Antediluvian Earth was not much greater than it is now, it could never reach so far into the Crust as to be able to raise Vapours from

the Abyfs: or if it was fo great as to be able to raife Vapours from thence, that is, if it was then as great upon the Surface of the Abyfs as it is generally upon the Surface of the prefent Earth, it muft have been almoft infinitely greater upon the Surface of the Antediluvian World. Certainly there could be no neceffity for a Deluge in that cafe, except it were to cool the Earth again after fuch an exceffive heat, which muft have deftroyed all the Animals, Plants, and Trees which were upon the earth, and have turned them into Glafs.

But perhaps it may be urged that the heat of the Sun does generate and prepare Metals which lie hid in its bowels; To which I anfwer, that I have already brought a fufficient demonftration that the heat of the Sun does pafs but a very little way within the earth, and therefore the Opinion that Metals are generated by the Suns influence muft be falfe; for they generally lie far hid within the bowels of the earth, and therefore without the reach of the Suns influence.

But the Theorift affirms further, that there was a continual Summer in the Antediluvian earth, and therefore if the heat of the Sun made a crack in the earth in one year, there being no Winter or Rains to repair the chaps that were made in the earth, this crack would continually grow deeper, till at laft it would reach to the Surface of the Abyfs. Let us

now

now bring this general way of speaking to a Calculation, and try if the heat of the Sun could this way reach the Abyfs. To determin which, I will suppose that through length of time, the Sun has made a crack in the earth of a Miles depth and one hundred foot in length extended from *East* to *West*, and let it be proposed to Calculate what proportion the heat upon any point of the Surface bears to the heat upon the bottom of the crack. In the Figure [*Fig. 1. Plate I.*] let $PSAQ$ represent the $\mathcal{A}$ Equator in which the Sun moves, PRT the Earth, PQ the sensible Horizon, and $PnmR$ the Pit made by the heat of the Sun in the Crust of the Earth: it is plain that the Sun shines on the point R on the Surface of the Earth all the time it is moving through the Arch PQ , but it shines only on the point m in the bottom of the Crack while it describes by its motion the Arch SA . Now the Action of the Sun upon any point is always more or less strong in proportion to the sine of the Angle of incidence of its Rays, that is, if the Sun be at S , and afterwards come to A , the action of the Sun upon the point R when it is at S , is to its action when it comes to A , as the sine of the Angle SRP is to the sine of the Angle ARP . From whence it follows, that the action of the Sun upon the point R is to its action upon the point m , as the sum of all the sines of the Suns Altitude while it shines

shines upon R is to the sum of all the sines of the Sun's Altitude while it shines upon the point m , that is if the times it shines upon R and m be taken for Basis's or the Arches PQ and SA which are proportional to them, be extended into straight lines HSAO, [Fig. 9. Plate VI.] and SA, and all the sines be erected on them perpendicularly, AE being the Sine of the Arch AH and SD the sine of the Arch SH, and the Curve line HDEO be drawn thorough the extremity of the sines, the heat upon the point R is to the heat upon the point m , as the space HDEO is to the space SDEA, But the Periphery PSAQ being a semicircle (for the Diameter of the Earth is but a point in respect of the Sun's distance from us) It is plain that the space HDEO is two figures of sines, which the Mathematicians have demonstrated to be equal to two squares of the Radius; and it is also by them demonstrated that the space SDEA is equal to a rectangle contained by the Radius and the sine of the Arch SA; but as I have already shewed the heat of the Sun upon the point R is to its heat upon the point m as the space HDEO is to the space DSAE. It is plain from thence, that the heat or action of the Sun upon the point R is to its action upon the point m as two squares of the Radius is to a rectangle contained by the Radius and the sine of the Arch SA, that

that is, as twice the Radius is to the sine of the Arch SA , by the first of the 6th of *Euclid*: But because Pn is to PR as 5000 is to an 100, or as 50 to 1, therefore by a trigonometrical Calculation the sine of the Angle SmA , or of the Arch SA is 19594 supposing the Radius a 100000, the heat therefore upon the point R is to the heat of the Sun upon the point m , as 200000 is to 19594, and consequently the one is more than decuple of the other. If therefore the heat upon the bottom of the Crack was so great as to reach further into the Crust, it must have been at least ten times greater upon the surface of the Earth; and if the heat of the Sun upon the bottom of the Crack was as great as is necessary for to raise the waters in the Abyss into Vapours, or as great as our Summers heat is, the heat upon the surface of the Earth must have exceeded the heat of red hot Iron, which is only seven times greater than the ordinary heat of the Sun in Summer.

But notwithstanding all this, should I grant to the Theorist that the heat of the Sun had reached the Abyss, and had raised the Vapours so that the crust of the Earth fell down and was broken in pieces, yet I cannot see how from thence there could follow any universal Deluge, or indeed any Deluge at all, tho' the Theorist does endeavour to explain it thus.

When

When the Earth says he, was broken and fell into the Abyfs, a good part of it was covered with water by the mere depth of the Abyfs it fell into; and those parts of it that were higher than the Abyfs was deep, and consequently would stand above it in a calm water, were notwithstanding reached and overtopp'd by the waters during the agitation and violent commotion of the Abyfs; for it is not imaginable says he, what the commotion of the Abyfs would be upon this dissolution of the Earth, nor to what height its waves would be thrown when these prodigious fragments were tumbled down into it. If you would suppose a stone of ten thousand weight taken up into the Air, a Mile or two, and then let fall into the middle of the Ocean, it is Credible that the dashing of the water upon that impression would rise as high as a Mountain; but if you will suppose a mighty Rock, or a heap of Rocks to fall from that height, or a great Island or Continent, these would expel the waters out of their places with such a force and violence as would fling them above the highest Clouds.

This is in short, the method the Theorist has found out for making an universal Deluge. But if I can prove from his own Principles, that long before the Deluge happened, all the Waters in the Abyfs were drawn up by the heat of the Sun to supply the Rivers that were necessary to water the Earth; I
would

would fain know what would become of his Deluge, or how he can make in that case the fall of the Crust to be the cause of an Universal Flood: for by all the conception that I can have of it, the water which was upon the surface of the Earth, by the fall would rush into the Abyfs; and it would be so far from making any Flood, that it would leave the surface of the Earth and make dry Land appear where formerly there was none. To prove this I must first enquire what proportion the quantity of waters which the Sea receives from the Rivers of the Earth in any time bears to the quantity of water in the Ocean; and by consequence I will Calculate the time the Rivers would take to fill the Ocean if it were empty, and they ran as they do now, or which is the same thing, I will find what time the Sea would take to empty it self into the Rivers supposing that it was not recruited again by the continual course of fresh waters, which run into it, that is, if the Abyfs did formerly supply all the Rivers with water, before the flood, and none of them ran into it again, as the Theorist supposes they did not, I am to find what time it would take to empty it self, on the surface of the Earth. And if I can prove that it would quite empty it self on the surface, long before the Deluge happened, I think from thence it would necessarily follow

low that there would be no Deluge at all, by the fall of the Crust.

To begin therefore, I will suppose as the Theorist has done, in his second Chap. Book first, that one half of the surface of the *Terra-queous* Globe is Sea, and the other Land, and that if we take the Sea one place with another, it is a quarter of a mile deep. Now the surface of the whole Earth being 170981012 *Italian* miles, the surface of the Sea is 85490506 square miles, which being multiplied by $\frac{1}{4}th$ (the Sea being $\frac{1}{4}th$ of a mile deep) the product is 21372626 $\frac{1}{2}$ Cubical miles, which is the quantity of water contained in the whole Ocean.

Now to Calculate the water the Ocean receives from the Rivers, we must consider some great river whose breadth depth and swiftness are best known, such is the *Po* which passes through *Lombardy* and waters a large Country of 380 miles in Length: *Ricciolus* in his *Geographia Reformata* tells us, that its breadth before its division into a great many Channels, by which it falls into the Sea, is a hundred *Bononian* Perches, or a thousand feet, and its depth is one Perch or ten Feet, and therefore its perpendicular Section, from one side to the other is a hundred square Perches, or 40000 square Feet: Its swiftness also is so great, that the course of the water is about four *Italian* miles
in

in an hour, or which is the same thing 2000 *Italian* Perches, for there are 500 Perches in a mile; The *Po* therefore carries into the *Adriatick* 200000 Cubical Perches of water, in the space of an hour, and therefore the quantity of water it brings into the Sea in a day is 4800000 Cubical Perches or 3800000000 Cubical Feet of water; but one Cubical mile contains 1250000000 Cubical Perches, and therefore if the *Po* takes one day, to bring into the *Adriatick* 4800000 Cubical Perches of water, it will require twenty six days, to carry into the Sea 1250000000 Cubical Perches, or one Cubical mile, or which comes to the same thing, twenty six Rivers every one of which is of the same swiftness with the *Po* will pour into the Sea one Cubical mile of water in a day.

I must in the next place determin what proportion all the Rivers in the Earth bear to the *Po*, which to determin exactly would be a task, not easily to be performed; but I think we may determin it near enough for our present purpose, by supposing that the quantity of water received into the Sea, by the great Rivers in any Country, is very near proportional to the extent and surface of that Country; And consequently the Country which is watered by the *Po*, and the Rivers which run into it, bears the same proportion to the surface of the whole dry Land, that the *Po* doth to all the Rivers in the Earth:
But

But I have observed from the exactest Maps I could see, that the *Po* from its Origin in the *Alps*, to its end where it runs into the Sea, is in length three hundred and eighty miles, and that the Rivers which fall into it from each side, come from Springs of about sixty miles distance from the *Po*; consequently the *Po* and the Rivers which run into it, water a Country which is 380 miles long, and 120 broad, all which makes 45600 square miles; but the surface of all the Land being equal to half the *Terraqueous* Globe is 85490506 square miles, and therefore according to the proportion formerly mentioned, the water which is carried into the Sea by all the Rivers, is 1874 times greater than what the *Po* carries into the Sea.

It is true, there are in the Earth some barren places which have no great quantity of water or Rivers in them, but they being but small will not much alter our account, and for an Equivalent, we can easily prove, that tho' there are some Countries not so well stored with Rivers as *Lombardy*, yet there are several others which are much better furnished with them, particularly the *South* part of *America*, where there are Rivers, which according to credible relations are above fourscore miles in breadth, and therefore by allowing a proportional depth, they will be several hundreds of times bigger than the *Po*.

Now

Now I have already Calculated, that twenty six *Po's* will pour into the Sea one Cubical mile of water in a day; and consequently in 365 days, or in the space of a year they will pour into the Sea 365 Cubical miles of water: hence it follows, that if 26 Rivers as big as the *Po*, pour into the Sea 365 miles of water, in the space of a year, from 1874 Rivers as big as the *Po*, there will be brought into the Sea in the same time 26308 Cubical miles of water; and therefore by the rule of proportionals, in the space of 812 years, the Rivers will bring into the Sea 21372626 Cubical miles of water, which is a quantity of water as great as the Ocean: and therefore in that time they would fill the great Channel of the Ocean if it were empty, and their course the same, both for quantity of water, and swiftness that it is now: And since the Sea furnishes the Rivers with all the water that runs through them, it is plain that the Sea would empty it self in the space of 812 years if none of the Rivers ran into it again.

Since therefore according to the Theorist, the Abyfs was the store-house which furnished the Rivers of the Antediluvian Earth with water, and none of them, according to him, ran into it again, and because all the waters which were antiently in the Abyfs, are now in the Ocean, it must needs follow, that in the space of 812 years it would be quite empty, upon supposition that there were as

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many Rivers in the primitive Earth as there are now in ours; but because there was then twice as much Land to be furnished with Rivers (there being then no Seas as the Theorist says) we must in proportion allow twice as many Rivers to water the double quantity of dry Land, and therefore by such a double quantity of Rivers, the Abyfs would be emptied in half that time.

Perhaps the Theorist will say, that the Rivers were not altogether furnished by Vapours drawn from the Abyfs, but by those also that were exhaled from the surface of the Earth, and that after the water in the Rivers had run towards the *Æquator* and middle parts of the Earth, the water was again raised into Vapours by the great heat of the Sun, and carried back towards the Poles in order to supply the Rivers again. But this is no objection to our present Argument, for tho' the Vapours drawn from the surface of the Earth, would no doubt encrease the quantity of water, in the Rivers, yet still there would be drawn from the Abyfs, the same quantity of Vapour as was before; the same cause still continuing to act, would still produce the same effect, and the Abyfs having at first furnished the Rivers with a sufficient quantity of water, would still continue to do the same, and in the same quantity; and therefore it signifies nothing against the former Calculation, how much Vapour was drawn

drawn from the surface of the Earth, or how much the Rivers were encreased by it.

Since then I have sufficiently proved on the supposition of his Principles, that all the water, in the Abyfs was long before the time of the Deluge, drawn out of the Abyfs, and placed on the surface of the Earth; I would fain know how in that case the Theorist can explain an Universal Deluge by the fall of the outward Crust of the Earth upon the Abyfs: for in my Opinion, this fall would have been so far from being the cause of a Deluge, that it would have proved the true way to deliver the Earth from a Deluge of waters which was then on it. For all the water which was in the Abyfs, being drawn up on the surface of the Land, and the Earth being of a Spheroidical and Oval shape, without Hills and Mountains, upper and lower Grounds, but exactly of the same Figure which its gravity and centrifugal force formed it into, when it was fluid; the great Mass of water which was then upon the Earth must have settled it self also in the same Figure, it having no banks to retain it within its Channel, or Mountains to keep it within bounds; and the true effect of the fall of the Crust, must have been to have discovered the Land, and the waters would have run from the surface of the Earth into the Abyfs, and there would have formed a Sea, and made that Land appear which before was covered with waters.

Notwithstanding what I have already proved, I will now suppose, that all the water which is now in the Ocean, was in the Abyfs at the time of the Deluge, and that the Crust of the Earth was broken and crackt, and fell down on the surface of the Abyfs; yet still I cannot understand how this fall could produce an Universal Deluge, and make the waters swell above the tops of the highest Mountains. For the Theorist has Calculated, that it would at least require eight Oceans of water to cover the face of the whole Earth, and raise the waters to a height that would be requisite for drowning of the world. Now there being but one Ocean of water in the Abyfs, how is it possible that any however violent agitation and force by which the waters were driven upwards, should multiply this one Ocean of waters into eight Oceans? this I am sure is a thing as impossible for him to explain as it is for me to believe: it is plain indeed that the fall of the Crust especially if there were any considerable distance between the Abyfs and it, would raise the waters to the tops of the highest Mountains, and would in some places produce a partial Deluge; but it is evident, that it is impossible in nature, let the motion be never so violent, that one Ocean should be sufficient to cover the whole Earth, and that above the tops of the highest Mountains, when eight Oceans are the least that can be required

required to perform such an effect. The waters indeed at different times, might have covered the whole Earth successively; first by making a Deluge in one place and then in another, but this could never have been brought to pass by the fall of the Crust at once. Besides the Scriptures inform us that the whole Earth was under water at the same time, and that *all the high Hills, that were under the whole Heaven, were covered*: now it is as impossible that one Ocean should suffice to drown the whole Earth, and cover the tops of the highest Hills, tho' for the space of one moment, as it is to make one pint of pure water fill a vessel which holds a Gallon. This Argument which I have now used is the Theorists own, which he has alledged in his 2d and 3d Chapters against all other ways of destroying the Earth by a Deluge; but he did not then observe, that it concluded as strongly against his own Theory, as it did against any other which pretends to explain the Deluge without the supposition of more water than what was Lodged in the Ocean or the Clouds.

But tho' I should suppose that there was sufficient water in the Abyss to cover the face of the whole Earth at once, yet I cannot conceive how such a flood of waters that was raised by the fall of the Crust, could last for so long a time, as the Scriptures inform us *Noah's flood* did, which was an hundred and

fifty days without abating on the face of the Earth. We know that water driven with great violence upwards falls down again in a very short space of time; and can we Imagine that the water which was raised by the fall of the Crust, could last many days, or indeed many hours without descending again to its ancient Channel? But the Scriptures assure us that the water in *Noah's* Flood continually encreased, and prevailed on the Earth for the space of one hundred and fifty days; it is plain therefore, that for this very reason the Flood of *Noah* could never be produced by the fall of this outward Crust of the Earth.

The Conclusion.

THERE are two sort of Arguments that may be brought against the Theory, the one depends only on the principles of Reason and Philosophy, and the other on the Authority of the writings of *Moses*: but these which might be gathered from *Moses* would be of no force against the Theorist; * since he denies the truth of his narrations, which he imagines to be invented by that excellent Law-giver to please and amuse the Jews: I have therefore in this Treatise only made use of Arguments which are drawn from Philosophy, which he cannot

* *Archæologæ Philosoph. p. 320. 321.*

not refuse to admit since he appeals to them, for the Truth of his own Hypothesis.

Because the Theorist tells us, that all things were made according to the three Mathematical sciences of Arithmetick, Staticks and Geometry, and that to understand the manner of their composition, we must proceed in the search of them by the same Principles, and resolve them into these again; I thought therefore I might fairly examin his Theory by the rules of those three Mathematical Sciences; and I hope that I have shown, that it is built on principles which are directly repugnant to each of them: But because Arguments drawn from the Mathematicks are not easily understood by those that are unacquainted with that Science, I have endeavoured to choose only those Arguments which are plain and obvious and which depend only on Arithmetick and the common principles of Hydrostaticks; so that except in one or two places, there is nothing in this Treatise but what may be easily understood by those who have a moderate knowledge in these Sciences.

The points I have examined according to these rules are, First, the Origination of the Earth from a Chaos, which as it is delivered down to us by *Moses*, must be undoubtedly owned by those who acknowledge the Divine Inspiration of that Writer; But as the Theorists method of forming the World is

not agreeable to the *Mosaick* History; so I think I have shewed that it is repugnant also to the Laws of Nature and Gravitation, which by his method could never have produced any habitable World.

2dly, The form of the Antediluvian World, which the Theorist says, was smooth, regular, and uniform, without mountains and without a Sea. This he asserts to be a necessary consequence of its rise from a Chaos; but I have proved that it is not so necessary, that an Earth arising from a Chaos, should be uniform and smooth as he supposes. I have also shewed the great use of Mountains, and how necessary they are for our subsistence in the present Earth, and that they are so far from being placed here without design, as the Theorist imagins, that there is scarce any thing in nature that shews more of wisdom and contrivance than they do, being absolutely necessary for the furnishing and maintaining Rivers with fresh waters; which is a demonstration that they were in the primitive Earth as well as they are in ours.

3dly, The right position of the Earths Axis, which I have proved to be so far from being excellent and fitted for a Paradisiacal World, that it would make the greatest part of the Earth not habitable. I have also enquired into the great advantages we reap from the present position of the Earths Axis, which is by far preferable to any other, especially

cially to the perpendicular position of the Axis of the Earth to the plane of the Ecliptick.

4^{thly}, The method the Theorist has found out to form the Antediluvian Rivers when there was no Sea to furnish them with waters, or any Channel or Ocean to receive them. This I have proved to be impossible on several accounts since the heat of the Sun could never bring up so much Vapour from the Abyfs, as would be necessary to furnish all the Rivers of the Earth with water; and tho' we should grant that Vapours were drawn from the Abyfs in places near the Equinoctial as he supposes, yet it is impossible that they should ever reach the Poles, there to form the Springs from which the Rivers were to run; Or if Vapours were once brought to the Poles by whatever cause we can imagin, yet it is impossible that they should ever run back from the Poles to the *Æquator*; since according to him the Earth was perfectly smooth and uniform without any upper grounds from whence the water was to descend to the lower places of the Earth.

5^{thly}, The Figure of the Earth which the Theorist rightly affirms not to have been exactly Spherical, because at the Commencement of the Diurnal rotation, it being Fluid all the parts of it would endeavour to recede from the Axis of their motion: but as he has guessed that it did settle into an Ob-
long

long Spheroidical or Oval Figure, on no other account, that I know of, but because he thinks such a one would best answer his design, so I think I have clearly enough demonstrated, that the Earth has formed it self into a quite contrary Figure, whose Axis is shorter than the Diameter of the *Æquator*; and I have proved from Observations, that the Earth is really of such a Figure.

6thly, The causes the Theorist has assigned for the breaking of the outward Crust which he affirms to be done by the great heat of the Sun. But this I have clearly proved to be a cause altogether insufficient for such an effect, since the heat of the Sun could never reach so far into so thick a Crust as to be great enough to raise water into Vapours. But lastly, granting the Crust to have been broken, and to have fallen down into the Abyss, yet I have proved from the Theorists own Principles, that there could follow no Universal Deluge, there being not so much water in the Abyss as was sufficient to cover the face of the whole Earth.

Throughout the whole Examination, I have observed the Theorists advice, and have considered only the substance of the Theory without making any excursions upon things that are accidental and collateral, which as he says do not destroy his Hypothesis. These are the main foundations on which his Theory is built, and since I have proved them

them all to be not only precarious, but impossible, his whole Hypothesis must fall with them. Perhaps many of his Readers will be sorry to be undeceived, for as I believe, never any Book was fuller of Errors and Mistakes in Philosophy, so none ever abounded with more beautiful Scenes and surprising Images of Nature; but I write only to those who might perhaps expect to find a true Philosophy in it. They who read it as an Ingenious Romance will still be pleased with their Entertainment.



SOME

SOME
REMARKS
ON

Mr. WHISTON'S

Theory of the Earth.

TH O' I think it impossible to give a True and Mechanical account, of that great Deluge of waters which once overflowed the Face of the whole Earth, it being a work not to be performed without the extraordinary contrivance of the Divine power; yet I cannot but acknowledge that Mr. *Whiston* the Ingenious Author of this new *Theory of the Earth*, has made greater discoveries and proceeded on more Philosophical Principles than all the Theorists before him have done. In his Theory there are some very strange coincidents which make it indeed probable, that a Comet at the time
of

of the Deluge passed by the Earth. It is surprizing to observe the exact correspondence between the *Lunar* and *Solar* year, upon the supposition of a circular Orbit, in which the Earth moved before the Deluge. It cannot but raise admiration in us, when we consider that the Earth at the time of the Deluge was in its *Perihelion*, which would be the necessary effect of a Comet that passed by at that time, in drawing it from a Circular to an Elliptical Orbit. This together with the consideration that the Moon was exactly in such a place of its Orbit at that time, as equally attracted with the Earth, when the Comet passed by, seems to be a very convincing Argument that a Comet really came very near, and passed by the Earth, on the day the Deluge began.

But notwithstanding this, I believe it will be evident by the following considerations, that a Comet could never have produced those various effects that Mr. *Whiston* has attributed to it; and it will also further appear that the Deluge was the immediate work of the Divine power, and that no secondary causes without the interposition of Omnipotence, could have brought such an effect to pass. But first I will make some Remarks on the Origin of the Primitive Earth, and method by which Mr. *Whiston* supposes it was formed.

Mr.

Mr. *Whiston's* first Hypothesis is, that the antient Chaos, the Origin of our Earth was the Atmosphere of a Comet; but this supposition, tho' he endeavours to prove it by several Arguments, doth not seem probable for the reasons following. First the Scriptures represent the Primitive Antient Chaos as a very dark and obscure Body; for they say, that it *was without form, and Void, and that Darknes was upon the face of the Deep*: this will further appear by the next verse, where God is said to have made light upon the first day of the Creation, which is a clear proof that there was none before that time, but that the whole Chaos was originally a dark and confused heap of Bodies. Now it is certain, by the Testimonies of all those who have made any Observations about Comets, that their Atmospheres are very bright and luminous Fluids through which the beams of the Sun diffuse themselves very freely, and many of them are again reflected back to us: and indeed, if we consider their pellucidness, and the vast quantity of Light which passes through them, without reflection, it is not easy to imagine how they should appear so lucid to our Eyes. Nor do I believe that it is possible to find among all the pellucid Bodies of our Earth any one, which being placed at the same distance from us, as the Atmosphere of Comets are, would appear so bright, or reflect the light
so

so strongly as they do. For it is easy to be observed, that diaphanous Bodies are not so luminous, nor do they reflect light in such a quantity as it is reflected from opaque Bodies. It cannot be said that the light by which we perceive a Comet, is only reflected from the top of its Atmosphere, and that it doth not pass through the Body of it to illuminate all the other parts of it, which are therefore involved in thick darkness; for it is evident that light passes clearly through the whole Body of the Atmosphere, and illuminates the central solid, which strongly reflects the light to us back again.

I know Mr. *Whiston* supposes, that this great darkness mentioned in the Scripture, proceeded from the subsiding of the vast Dense and heavy Fluid, or large Abyfs, which he says encompassed the central solid, and was it self covered over with a collection of Earthly, Watery, and Airy particles, intercepting and reflecting all the Rays of light which fell upon it: but this I think doth not well agree with the tenour of Scripture, which represents the Chaos in its very Original state, as involved with darkness and obscurity. It is also repugnant to all the ancient Traditions we have about it, which represent it as a dark and confused heap of Bodies, from the very beginning of its existence, till the time of the Creation or Formation of the Earth. It is plain also that the
Abyfs

Abyfs or Deep mentioned in Scripture, could not be that dense and heavy fluid Mr. *Whiston* speaks of, on which he says the upper Crust of our Earth is founded; it being certain, that the Scriptures are to be understood of an Abyfs which was then dark, and afterwards when light was created, was illuminated and made visible. For when light is said to have been made, without doubt we must suppose, that it was produced in some place which before was involved in darkness, and then exposed to the light, which can never agree with Mr. *Whiston's* Abyfs, which he makes to be encompassed with a dense and opaque Crust perfectly impenetrable by the light of the Sun. It appears therefore, that this darkness mentioned in the Scriptures must be understood to be somewhere else than on the Surface of a dense and heavy fluid that surrounds the central solid.

It is also to be observed, that it is not easy to conceive how these Earthy, Watery, and Airy particles, should fall so thick and fast on one another, as would be sufficient to intercept all the light which fell upon them, and quite darken the Atmosphere, without suffering the least glimmering of light to pass through them. For as Mr. *Whiston* observes, the heat of a Comet when it passes its *Perihelion* is so excessively great, as to last many thousand years; and we cannot doubt but that great commotion and confusion which

which is raised by this heat must last proportionally, and as the heat doth gradually decrease, so must the commotion in the Atmosphere decrease proportionally: by which the most solid and heavy Bodies would soonest fall down. And one would think that it would not be the work of one or two years, but it would require some thousands of years after the solid Bodies first began to fall, before the Atmosphere could settle it self into a regular and uniform Body. And therefore since all these diaphanous and solid Bodies which composed the outward Crust fell so slowly and by degrees on the Abyfs, and since at the time they were all there, they were not able to darken the Atmosphere; I think that by their slow and gradual descent, they would not fall so thick upon one another, but that the Comets Atmosphere would still be penetrated and illuminated by the light of the Sun.

But if I should grant to Mr. *Whiston*, that there were such dark and thick Clouds in the Atmosphere of the Comet as were sufficient to intercept all the light that should be derived to it from the Sun; yet if we consider that the central solid of a Comet, is a Body which by reason of its near approach to the Sun, is scorched and burned by very intense heat, and that all solid and hard bodies when they are heated to any considerable degree are clear and luminous; we must acknow-
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ledge that the proper and native light of Comets, if I may so call it, is very considerable; and therefore upon this single account of a Comets proper light, it cannot be such a dark and obscure Body as that Chaos was, from which the world had its Origination.

Since then the Atmospheres of Comets are clear and pellucid luminous Bodies, through which we can distinctly view their central solids; and since the Chaos out of which the world was made from its very Original, was a dark and confused heap of Bodies without the least glimmerings of light, which was not created till the first day of the Hexaëmeron; it is plain that this Chaos could never be the Atmosphere of a Comet, and therefore Mr. *Whiston's* first Hypothesis is but ill grounded.

It is also to be observed, that the greatest part of these solids, which compose our upper Stratum, consist of Stones, Sand, and Gravel; and that they when they are once heated to any considerable degree, are necessarily melted and turned into Glass. Now if they had ever existed in the Atmosphere of a Comet, when it was near the Sun, they must have sustained a degree of heat some hundreds of times greater than the heat of red hot Iron; and consequently they must have been melted: and during the time of their immense heat they would have composed a
fluid,

fluid, which afterwards when the Comet was cooled, would appear in the form of Glass; by which it is plain, that those Bodies never were in the Atmosphere of a Comet, for otherwise they could never have appeared to us in the form they are in at present.

Mr. *Whiston* asserts, that there are very many, and very considerable Phænomena of nature, which require a central force, or internal heat, diffusing warm steams every way from the centre to the circumference; and especially he seems to be pleased with Dr. *Woodwards* method of raising Vapours through the Earth to furnish the Rivers with water by the help of a central fire; which he thinks is easily accounted for, by supposing the interior solid of the Earth to have been the *Nucleus* of a Comet, that once in its approach to the Sun had acquired an immense heat which it doth still in a great measure preserve: but this Opinion, tho' it has been maintained by a great many Learned Men, seems to be very improbable. For if I should suppose that there was such a central fire, yet it is not to be imagined, that it could ever diffuse it self, and penetrate the exterior parts of the Earth. We know by experience, that if a stone wall of four or five foot thickness be heated red hot upon one side, that the other continues as cold as before, without being sensibly affected with the heat which is in-

tense on the opposite side. Since then we see that an intense heat is not able to penetrate through a stone wall, how can we suppose, that it should diffuse it self through a dense and heavy fluid, an hard and diaphanous Crust of some hundreds of miles thickness?

I know none of the Phænomena of nature that do necessarily require a central fire. For as to burning Mountains and Volcano's, if Mr. *Whiston* will be pleased to consult *Borelli de incendiis Montis Ætnæ*, he will easily be convinced, that its fire doth not proceed from the Centre, but that its kindled very near the surface of the Mountain. And as for Rivers, I believe it is evident, that they are furnished by a superior circulation of Vapours drawn from the Sea by the heat of the Sun, which by Calculation are abundantly sufficient for such a supply. For it is certain that nature never provides two distinct ways to produce the same effect, when one will serve. But the increase and decrease of Rivers, according to wet and dry Seasons of the year, do sufficiently shew their Origination from a Superior circulation of Rains and Vapours. For if they were furnished by Vapours exhaled from the Abyss through subterraneous Pipes and Channels, I see no reason why this subterraneous fire, which always acts equally, should not always equally produce the same effect in dry weather that it does in wet. Besides this, since the Mountainous

tainous Columns are erected not on the Surface of the water, but stand immediately on that dense and heavy fluid which covers the central solid; I cannot easily conceive how water should ever come to the bottom of the Fissures to be raised into Vapours. Nor can I well conceive that prodigious heat, that must be sufficient to raise as much Vapour through some small Fissures in Mountains as the heat of the Sun is able to do from the whole Surface of the Sea.

I know the maintainers of this Opinion use to alledge, that there are Springs and Fountains on the tops of Mountains, which cannot easily be maintained by a Superior circulation of Vapours: but I beg those Gentlemens pardon, for I can give no credit to any such Observations; for I am well assured, that there are none of those Springs in some places where it is said they are. And particularly that Learned and diligent Observer of Nature Mr. *Edward Lloyd* the Keeper of the *Museum Asmoleanum* assured me, that throughout all his Travels over *Wales*, he could observe no such thing as a running Spring on the top of a Mountain. On these considerations, I think it is not in the least probable, that Rivers and Springs proceed from Vapour, that is, raised by a subterraneous heat through the Fissures of the Mountains.

I come now to consider the way Mr. *Whiston* makes use of, to explain the formation

mation of the Sun, Moon and Stars, by which he says in the *Mosaical* account of the Creation, no other thing is understood than the rendering of them visible and conspicuous to a Spectator on the face of the Earth: for before the fourth day according to him, the Air was much crowded with thick and opake Clouds, which would very much darken the face of the Earth, and keep a Spectator on it from being able to perceive either Sun, Moon or Stars, which were created long before that time. In this place I think Mr. *Whiston* has not exactly observed his first *Postulatum*, viz. that the obvious and literal sense of Scripture is the true and real one, where no evident reason can be given to the contrary. For since the formation of the Sun and Stars at that time was possible, and the Scriptures positively tell us, that they were made by God Almighty at that time; I think there can be no evident reason given which will be sufficient to justify such a forced and strained sense as he has here put on the words of Scripture.

But tho' I should suppose that the literal sense of Scripture did not in the least contradict such an exposition, yet it appears to be impossible on his Hypothesis for these reasons. First, I have already proved that the Atmosphere of a Comet is a very clear and pellucid Body that doth freely admit both the light and heat of the Sun through it; and consequently there is no doubt to be made,
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but that an Eye placed within would have the Sun very visible and conspicuous to it. It is evident therefore, granting this Hypothesis of the Earths being formed from the Atmosphere of a Comet, that the *Mosaick* account of the formation of the Sun and Stars can never be understood of rendering them visible; since according to such an Hypothesis they must have been always so.

2^{dly}, Whatever Mr. *Whiston* may imagin of the Sun, yet it is certain that the Moon at the time of the *Mosaick* Creation was formed or at least placed in its orbit, and made to turn round the Earth; for no Comets have any secondary Planets which move round them: since then the Moon did not before that time appertain to the Earth but was really at the time of the *Mosaick* Creation, if not Created and formed, at least brought into a new orbit, and made to move about us to give us Light in the night time; we must necessarily acknowledge, that when God is said to have made the Moon, there must be something more understood than a mere rendering of it visible; and because the word *Made*, is equally applyed in Scriptures both to the Sun and Moon; there is no doubt but that it is to be understood in the same sense of both, that is in a literal one, *viz.* That they were really Created, when in Scripture they are said to be made on the fourth day of the *Mosaick* Creation.

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3dly, Mr. *Whiston* supposes that the Sun acted so very strongly the second day of the Creation on the Earth, that it was able to draw a prodigious quantity of Vapours into the Air, such as were sufficient enough when they fell in Rain, to produce all the Seas, Lakes and Rivers that were in the Primitive Earth: but how the Sun could have such an extraordinary influence on the Earth without being visible, is a question which I believe cannot be easily answered; for there is a great difference between the heat of the Sun when it shines bright and clear, and its influence when it is obscured with Clouds and Vapours; Indeed one would think that it would require a prodigious heat, to elevate such a quantity of Vapours in one half year, as would fill all the Channels of the Seas and Lakes with water. I am sure that the Sun now when it is brightest is not able to perform any such effect; for if we should collect all the Rain that falls in the space of a year on the surface of the Earth, it would not rise, on the whole surface of the Earth, above a foot and a half high; which is not enough to make the thousandth part of an Ocean. Since then according to Mr. *Whiston*, the Sun was capable on the second day, to perform an effect some hundreds of times greater than its heat when it shines clearest and brightest is able to do on our Earth, I think we may undoubtedly conclude that it must have been
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visible even at that time; that is, it must have been visible before it was said to have been made, which cannot be imagined in whatever sense we take the word *made*.

Indeed I cannot but think it strange, that Mr. *Whiston* should suppose, that there was some hundreds of times more water drawn by the heat of the Sun in one half year, than there is now exhaled from our Earth in double that time; since he himself acknowledges, that we do every day enjoy more of its Heat and Light than the Primitive Earth could be supposed to have done for a considerable space of time: this I confess seems to me, to be a very wonderful and unaccountable effect, and not at all proportional to its cause; but if he will suppose that it was really so, I need not argue much against it, since I am sure, such a supposition must necessarily allow the Sun to have been at that time visible.

Mr. *Whiston's* third Hypothesis is, that the diurnal rotation of the Earth, did not commence till after the fall; so that till that time, Days and Years were exactly equal and the same; the Earth having no other motion but its annual one round the Sun, all the World would have for one half of the year a continual Day, and for the other a continual Night. Here I must freely own my self to be one of those Readers to whom Mr. *Whiston* says this assertion will appear one of the greatest of Paradoxes; for when I consider the vast and prodigious

digious cold that must be occasioned on the Earth, by the total absence of the Sun for one half year together, I think that it would be so excessively great, as that 'twould have been impossible to be endured by Creatures made of Flesh and Blood. We are extremely sensible of the great cold we sustain by having our Night in the Winter sixteen hours long, but yet it is nothing to what it would be, were the Sun for half a year together absent from us: how cold and uncomfortable a darkness must that have been in which our first Parents passed the one half of their Paradisaical life, when in the other half they must have been scorched and roasted with the immense heat of the Sun, which shined on them continually for as long a time, as they were before in the dark. This heat in my opinion, would have quite withered the Herbs and Plants which were then designed to be the food of Mankind; it would have forced our first Parents to seek for shelter in Dens and Caves, which would have been, in such a state, more convenient than the Garden of *Eden*; and it would have been altogether as unsupportable as the former cold. It is evident that such a state would be so far from being agreeable with that happy and pleasant Paradisaical life which our first Parents are said to have lead in their state of Innocency, that the *Legend-makers* and *Poets*, thought it a fitter representation of Hell and its Torments, than of that state of happiness;

happiness; some of them having feign'd that there were Ghosts brought from Hell on purpose to inform us that a great part of the miseries of the damn'd consisted in their being driven from extreme hot places to extreme cold ones.

There is one very convincing Argument against this supposition arising from the consideration of the nature of Animals, whose Blood and other liquors that run in their Bodies are not able to endure two such opposites as the extreme heat caused by the Sun while it shined for one half year without intermission on the same place; and the extreme cold that must arise through his absence for the same time. For if we should suppose that these animal liquors were of such a constitution and internal heat as not to be frozen by an extreme cold, yet it is certain that they must evaporate and be exhaled by the extreme heat that came after it in the day time: or if they were able to sustain such an extreme heat without evaporation; then without doubt they could not preserve themselves from freezing in an extreme cold which they must have suffered in such a Winter or half a years night.

I know there are Animals which live near the fire, and are able to endure an extraordinary heat; as there are others that live near the Pole and in very cold Climates: but it is not imaginable there can be any such that
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can live both in excessive heat and excessive cold; it being impossible that ever they can endure two such opposite extremes. Tho' this seems to be a very pressing difficulty against such an Hypothesis, yet there is another that I think as insolvable, arising from the consideration of the nature of Plants.

We know that there is a certain determinate degree of heat necessary for the production and vegetation of most Herbs, and for the ripening of their Seed so that a less degree of heat would never bring the Plant to perfection, and a greater would quite wither it before its Seed could be ripened and fit for the production of a new Plant of the same species. It is easily observable how great difficulty there is, and how much pains must be taken, by hot beds, and other artificial helps to raise Plants in this Climate, which are transplanted hither from the *Torrid Zone*: but this difficulty proceeds no doubt, from the want of such a due influence of the Sun as was necessary for the production of these Plants; so that by reason of the great difference between the heat which they had in their own proper Soil, and that which they participate of here, it is hard to bring them to perfection: but if we should suppose this alteration to be some hundred of times greater than it is, without doubt we should conclude it impossible for any such Plants to grow with so little a degree of heat. But
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this must have been the true case of the Plants in the Primitive Earth: At first before the diurnal rotation of the Earth began, they sustained a degree of heat some hundreds of times greater, than the greatest heat we have in Summer; but after the Earth began to turn round its Axis, the heat and action of the Sun on them came to be of the same force and tenour that it is of at present; but I have observed before, that all plants and Herbs require a certain determinate degree of heat and influence from the Sun; and as a much greater heat will wither them, so less will never bring them to perfection: on which account it seems to be naturally impossible, that ever any of these Plants, whose nature and constitution was fitted for the heat of the Sun, before the commencement of the Earths diurnal rotation, could ever be brought to perfection after it began to turn round its Axis in the space of twenty four hours, by which the action of the Sun would be very much less than before. If therefore the Earth had no diurnal rotation till after the fall; and if then only it began to turn round its own Axis, there must have been such great and extraordinary changes and alterations of heat and cold introduced by this new rotation, as would necessarily require new Species of Plants and Vegetables of different natures from the former ones, which would better agree with the new rotation and constitution of
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of the Earth, and the action of the Sun. That is, God Almighty must have created new and different sets of Plants, or at least have quite altered and changed the natures of the old ones, which we can hardly imagin to be done.

It is on the account of these reasons that I cannot be induced to believe Mr. *Whiston's* Hypothesis, that the Earth had no diurnal rotation before the fall, to be probable; it seeming to be far more agreeable to the Laws of Nature and Philosophy, that the Earth received both its annual and diurnal motions at the same time, *viz.* when it was first Created.

These are the chief and principal Remarks that I have made on the Original State and Formation of the Earth; I will now briefly consider his Theory of the Deluge which is in short thus.

He supposes that a Comet at the time of the Deluge came very near and passed by the Earth; that the Comet, when it came below the Moon, would raise a vast and strong Tide, both in the Seas that were then on the Surface, and in the Abyss, which was under the upper Crust of the Earth, after the same manner as the Moon doth at present in the Ocean; that this Tide would begin to rise and encrease all the time of the approach of the Comet; and would be at its greatest height, when the Comet was at its least distance

distance from the earth. By this tide and the attraction of the Comet, he supposes that the Abyss would put on an Elliptick or rather an exactly oval figure; whose surface being much larger than the former spherical one, the exterior crust of earth, which lay upon it, must conform it self to the same figure, which it could not do as long as it remain'd solid and conjoin'd; and therefore it must of necessity by the violent force of the tide be stretched and broken, and have innumerable fissures made quite through it. After this he supposes that the Comet in its descent towards the sun passing close by the body of the earth involved it in its Atmosphere and tail for a considerable time, and left prodigious quantities of condensed and expanded vapours on its surface, a great part of which being very much rarify'd after their primary fall, would be immediatly drawn up into the Air again, and afterwards descend in violent and *outragious* Rains upon the Earth; and would be the cause of the forty days rain mentioned in Scripture. The other great Rain, which together with the former, lasted an hundred and fifty days, was occasioned as he thinks, by the Earths being involved a second time in the Comets tail; from which, and from its Atmosphere he derives one half of the water, which served for the Deluge. The other half he supposes was deduced from

from the subterraneous Abyfs, the fluid whereof he says was forced upon the Surface of the Earth, by the vast and prodigious pressure of the incumbent water that was derived from the Comets Atmosphere and Tail, which he supposes, would press downwards with a mighty force, and endeavour to sink the outward Crust of the Earth into the Abyfs: by which vast quantities of the subterraneous fluid, would be forced and raised upon the Surface of the Earth, through the Cracks and Fissures, that were made in the Crust by the violence of the Tide in the Abyfs. By these methods Mr. *Whiston* supposes that there was water enough brought on the Surface to cover the face of the whole Earth for the perpendicular height of three miles, that is, above the tops of the highest Mountains. But he further supposes, that neither that water which was derived from the Comet, nor that which was forced up from the bowels of the Earth, was pure Elementary water, but rather a thick and muddy fluid, which he says being heavier than water, sunk to the bottom and covered the Earth, for the depth of 166 feet. After having thus formed the Deluge, his next great work is to remove these waters which were brought on the Earth; and this he supposes to be performed by a wind, which dried up some, and forced the rest through the Cracks and Fissures
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of the Earth into the Abyſs, in which a great part of them had been before, and from whence they were derived.

These are the suppositions by which Mr. *Whiston* pretends to account for all the Phænomena of the Deluge. But tho' I can easily allow the first Hypothesis to be true, *viz.* That a Comet at the time of the Deluge came very near and passed by the Earth, since its approach at that time is not only made possible but also very probable by him; yet I cannot admit of the particular explanations he has given of several of the Phænomena of the Deluge; a great many of them, as he has explained them, seeming to be no ways agreeable to the Laws of Mechanicks and Philosophy.

For first, tho' it is certain, that a Comet, when it passed by the Earth, would raise a very strong and prodigious Tide in the Seas that were then on the Surface; yet I cannot perceive that such an effect would be produced in the Abyſs, which he supposes to be a dense and heavy fluid encompassed on all sides with a thick and solid Crust of Earth lying closely upon it. For Tides being only a violent swelling and motion of the waters produced by the attraction of some great Bodies that come near them, if we should suppose that the waters were every where shut up within a solid Orb lying on them, so that there were no room or space left for

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them to move in, it is plain that in such a case there could be no Tide or agitation of the waters, but they would remain in the state they were in before; nor could they press stronger on that Orb which enclosed them, than Sand, Gravel, or any other firm and hard Bodies would do, that could fill their place; all Bodies whether firm or Fluid, being equally attracted, when the attracting Body is at the same distance from them. This being then the true case of the Abyfs, which Mr. *Whiston* supposes to be enclosed by the thick solid and upper Crust of the Earth, which pressing so close upon it as to leave no void space, at least not such a one as would make room enough for any considerable commotion of the waters; and because fluids are not more attracted than solids are; it is plain that by the Tide of the Abyfs, and the attraction of the Comet, there could never be produced any greater effect on the Crust, which encompassed the subterraneous fluid, than if the whole Earth had consisted of firm and solid matter, without any Abyfs. It is certain therefore, that since there was no tide in the Abyfs, there could be no cracks and fissures made in the Earth by it.

To explain the great rains, which fell on the Earth during the time of the deluge, Mr. *Whiston* assumes a proposition which I believe he can hardly prove, *viz.* that after the Earth was involved in the Comet's Atmosphere

sphere and tail, and had acquired a prodigious quantity of condensed and expanded Vapours that fell on its surface, a great part of them being much rarify'd, would be drawn up again into the Air, and afterwards descend in violent and outrageous rains. Now if we consider the incredible velocity, with which these Vapours descended (which Mr. *Whiston* calculates to be so great, that they descended eight hundred and sixty eight miles in a minute) and the great resistance they met with in their descent through the Air, and the force by which they fell on the ground; we must necessarily acknowledge, that they must have been condensed and turned into Water, by such a resistance and fall. For it is certain, that when Vapours fall, they must meet with a great check and resistance from the Air, by which their parts will be pressed close together; and as their velocity encreases, so would the resistance and their density till at last their parts come to be as closely united as it is possible, and then they'd fall in the form of Water. Thus it is without doubt, when it rains; for we must not imagine, that rain drops have the same form and density in the Clouds with which they arrive at the ground, for Water being of a greater intensive gravity than Air, it is impossible, that it should be sustained in it, but when it is expanded into Vapour.. Now it is plain by observations on the Baroscope, that, when-

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ever the Vapours begin to descend, the Air is lighter than it was before; it therefore not being able to sustain them, they must fall to the ground; but in their way they meet with a great resistance, and check from the Air, and so must necessarily be condensed and fall in drops of Water on the ground. And since the resistance of the *medium* is always as the square of the velocity with which the Body moves through it, and because the velocity of vapour which fell from the Comet to the Earth, must have been according to Mr. *Whiston*, some thousands of times greater than the velocity with which common Vapour or Rain descends, it must needs follow, that the resistance the Vapour, which was derived from the Comet, met with, was some millions of times greater than the resistance of common Vapour when it descends; but the resistance of common Vapour, when it descends, is great enough to condense it into water; it is evident therefore, that all such Vapours as descended from the Comet must have been of necessity condensed into water long before they ever touched the Earth. Seeing then they descended on the Earth in the form of water, and seeing there was no sufficient cause that could immediately raise and mount them up again, the heat of the Sun not being great enough for such an effect; it is plain, that they could never rise up again to produce the forty Days Rain mentioned in Scripture.

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Mr. *Whiston* having, as he imagins, explained the great Rains, which fell on the Earth at the time of the Deluge, doth in the next place proceed to shew, how the waters of the Abyſs were forced up to the Surface of the Earth, and became a great cause of the Universal flood. This he supposes to be performed by the vast quantity of waters, that had descended from the Comet, which, he says, being of a prodigious weight would press the Crust of the Earth downwards with a mighty force, and endeavour to sink it deeper into the Abyſs; by this pressure the waters of the Abyſs would be forced upwards through the Cracks and Fissures newly made by the violence of the Tide on the Surface of the Earth. He endeavours to illustrate this method of Operation by the Example of a Stone or Marble Cylinder, exactly fitted to a hollow Cylindrical vessel, that it may just ascend or descend freely within it: He supposes the Stone Cylinder to have holes bored in it quite through, parallel to its Axis, and let down in the hollow Cylinder, which is half full of water, till it touch the water; then if each of the holes be filled with Oil or some other fluid lighter than water, he says that the weight of the Cylinder pressing on the water, would squeeze the Oil on its Surface through the holes, and throw it out with some violence, and this would be a just representation of the Deluge.

I must beg Mr. *Whiston's* leave to think this experiment very far from being any way a just representation of the flood; the case being very different, when the Solid is specifically heavier than the Fluid in which it is put, from what it is, when the Solid is specifically lighter than it. In the one case, the Solid would descend and force both Oyl and water up with a considerable force, if the holes be sufficiently small: In the other case, when the lighter Solid is put down, and swims in the fluid, neither Oyl nor Water can ascend, because the Body it self cannot descend. Now by Mr. *Whiston's* own Hypothesis, the Crust of the Earth is lighter than the Fluid in the Abyfs; and therefore it is clear, that it can neither descend as the Stone Cylinder would do in water, nor force the Fluid in the Abyfs to ascend, by its pressure. This will clearly appear by Mr. *Whiston's* representation a little rectified. For if instead of the Cylinder of Stone, we should take a Cylinder of Wood, which is lighter than Water, and bore it through with holes as the other was, and put it into the Water, till it swims, and afterwards pour Oyl into the holes; it is plain that neither Water nor Oyl could ever be raised to the top of the Cylinder: Nay the Water would be so far from rising higher by the additional pressure of the Oyl, that I can demonstratively prove, it would fall lower, and the Solid would not
sink

sink so far into the Water, as it did before the Oyl was put in. [*Fig. 10. Plate V.*] For let *A B C D* represent a Vessel half full of Water, in which *F* is a Solid swimming; it is evident, that the Solid will so far descend in the Water, till the Surface *i k* of the Water be as much pressed by the weight of the Solid, as the Surfaces *h i*, *k l* are by the weight of the incumbent fluid.

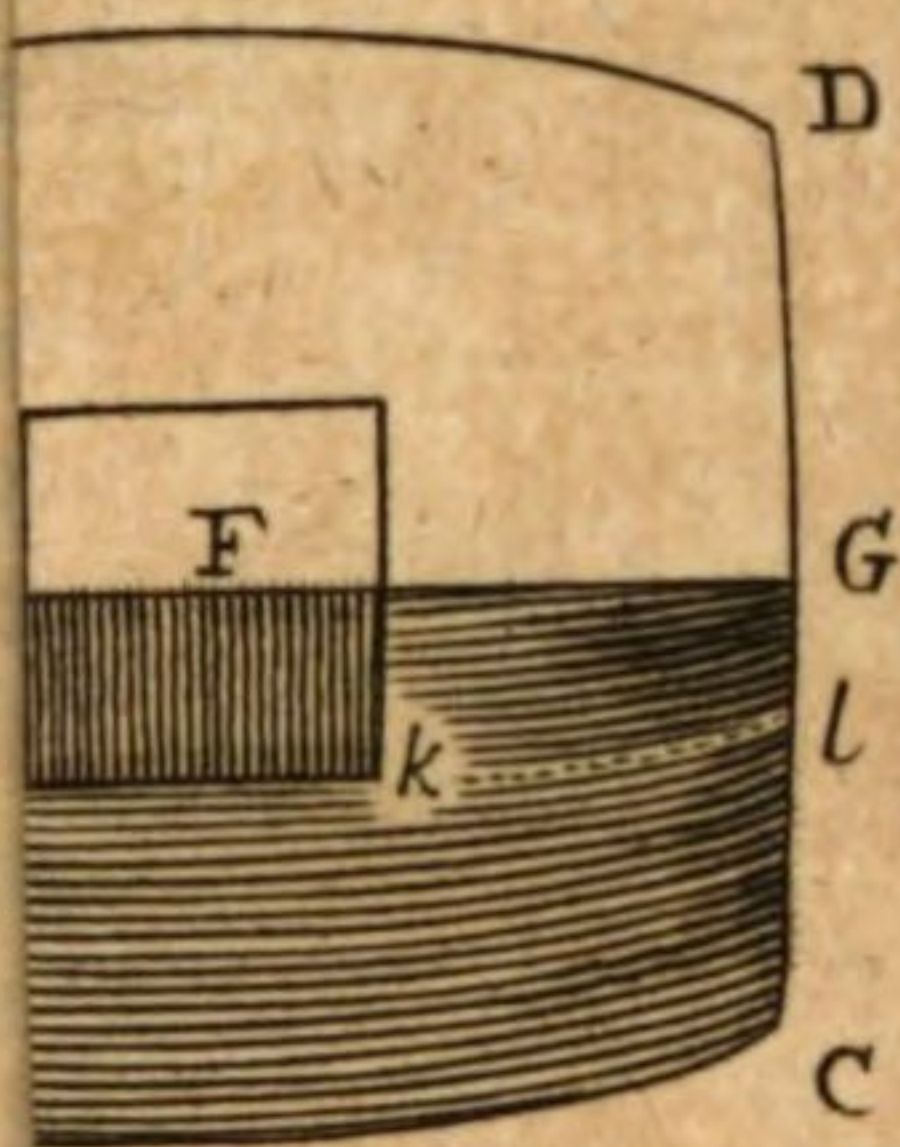
Now if we should pour Oyl into the same Vessel above the Water and above the Solid, as in the Figure, [*Fig. 11. Plate V.*] where *m E G n* represents Oyl; it is plain, that the Surfaces *h i*, *k l* are pressed with the additional Columns of Oyl *m E o r*, *q p G n*, which being greater than *r o p q*, the additional Oyl wherewith the Surface *i k* is pressed, will have a stronger pressure than the Surface *i k* has; and therefore the Water at *h i*, *k l*, being more pressed than that which is at *i k*, it must descend, and force that which is at *i k* further up: that is, the Solid will be forced upwards, and will be so far from being heavier than 'twas in respect of the water, that it will be relatively lighter; and this must have been the true case of the Water at the Deluge. For when it fell on the Surface of the Earth, it would descend into all the Cracks and Fissures thereof, till it had quite filled them; for water cannot lye on any Surface except all the Holes and Fissures of that Surface be first filled. This adventitious water in the Fissures pressing more

strongly on the Surface of the Abyfs than the Water, which lay on the Surface of the Crust could do, would force the Fluid immediately under it to descend, and that which is under the Crust to ascend. Thus I think, it is absolutely certain, that in this case, the water in the Abyfs would be so far from being able to ascend, that it must necessarily descend by the pressure of the incumbent water; and the whole Crust must have been raised higher, not immerg'd deeper in the Abyfs.

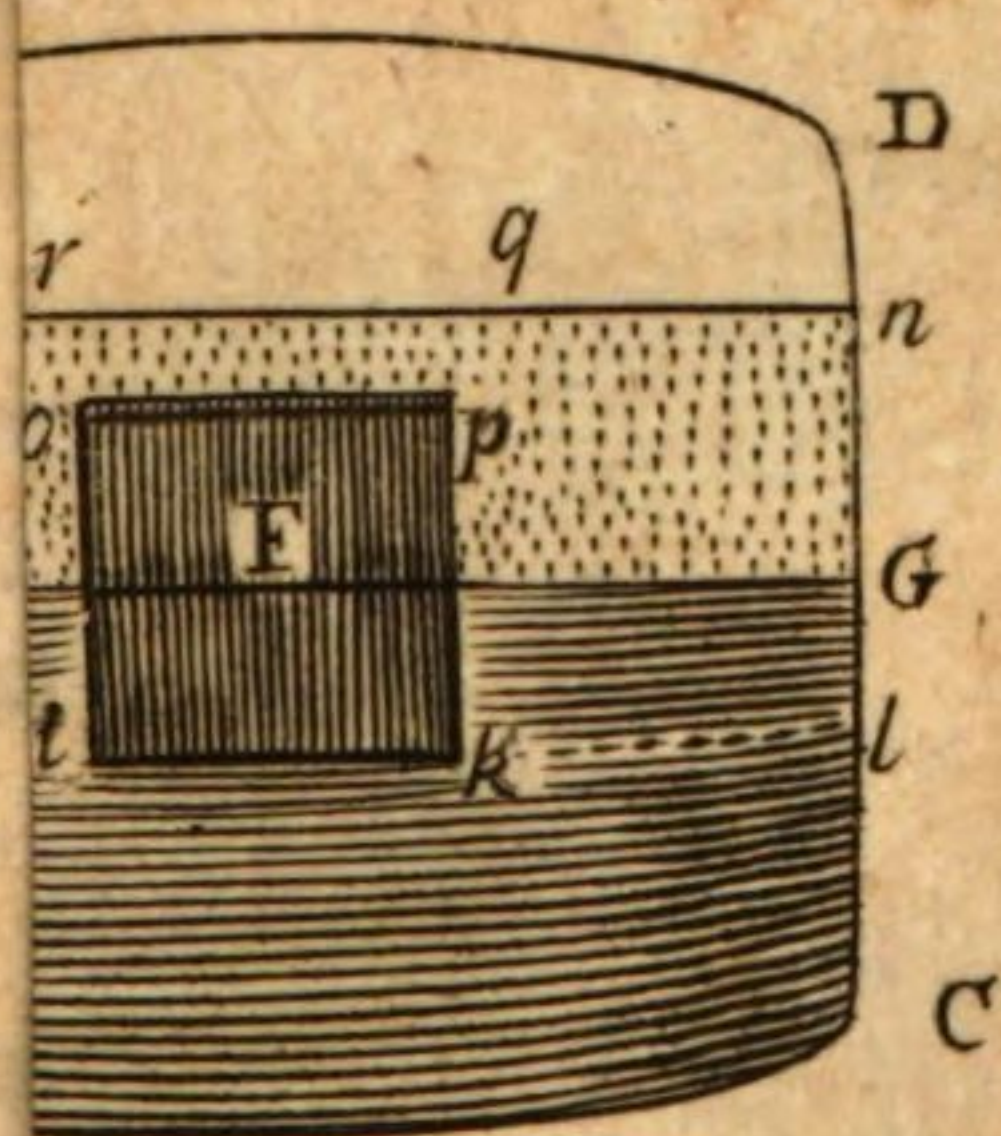
There is but one possible case, wherein the pressure of the water could sink the Crust deeper into the Abyfs, and that is, if the waters which lay on the Surface, could not descend through the Cracks and Fissures of the Earth. And tho' I can see nothing that can hinder them from descending; yet if I should suppose, that they did not, I can evidently prove by Calculation, that such a pressure could never raise the Abyfs above the Surface of the Crust.

To demonstrate this, I assume the height of the water, which was derived from the Comet, to have been a tenth part of the thickness of the whole Crust; tho' doubtless this is much greater than in reality it can be allowed to have been: and because, according to Mr. *Whiston*, the Columns of which the Crust is composed, are about four times heavier than common water, it follows, that a Column of the same specifick gravity with the rest of the
Crust,

Plate V.



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Crust, whose base is equal to the base of the incumbent Column of water, and one fourth part of its height will weigh as much, or press the Crust as much downwards as the whole Column of water could do; but the height of the water being a tenth part of the depth of the whole Crust, the height of the additional Column that weighs as much as the water, must be a fortieth part of the depth of the Crust. From hence it follows, that the height or thickness of the Crust before the additional Column is laid on, is to its thickness after the additional Column is laid on, as 40 is to 41. The whole problem then is plainly reduced to this; Having two Cylinders or Columns of the same intensive gravity, but of different heights that swim in any Fluid, to find what proportion the parts or heights immersed bear to one another. By a known proposition in Hydrostaticks, the part immersed of each Cylinder, bears the same proportion to the whole Cylinder, that the intensive gravity of the Cylinder bears to the intensive gravity of the Fluid; from thence it is evident, that the parts immersed have the same proportion that their respective whole Cylinders have to one another; which in the present case is as forty to forty one. By this it is clear, that the additional weight of the incumbent water would not sink the Crust above one fortieth part deeper into the Abyss, than it was before; and therefore it
could

could never rise by such a pressure so high as the Surface of the Earth. But if we should suppose that the pressure on the Crust should be so great as to press the Abyfs upwards, and the waters in it to the Surface of the Earth; it is certain, that in such a case, when the waters in the Abyfs had ascended to the Surface, there must be a communication between the Abyfs and it: by this communication, the waters on the Surface must necessarily descend and lye immediately on the Abyfs; and so the case would be reduced to the former one, where the water is supposed to press immediately on the Fluid in the Abyfs; by which pressure, the Crust would be so far from sinking deeper, that it would be raised to a greater height, as I have shown before. From all this it is demonstratively evident, that by no sort of pressure of the incumbent fluid the Abyfs could be forced upwards to spread it self on the Surface of the Earth.

Another Argument, which may be urged against deriving water from Mr. *Whiston's* Abyfs, is this; He supposes the Abyfs to consist of a very dense Fluid, whose intensive gravity is greater than the gravity of the Crust which subsided into it: but this Crust being three or four times heavier than water it must be immediately contiguous to the Abyfs; so that there can be no room for any considerable quantity of water to lye between them;

them; and therefore it is plain that whatever water was raised from the Abyfs must be only on the Cracks and Fissures of the Earth. But Mr. *Whiston* supposes that the half of that water at least which was necessary for the Deluge was derived from the Abyfs, that is, as I shall hereafter prove, there must have been eleven times more water derived from the Abyfs than there is in the whole Ocean; which is a prodigious greater quantity than the Cracks and Fissures can be supposed able to contain. Perhaps Mr. *Whiston* will grant, that the greatest part of what was drawn from the Abyfs was not pure water, but that dense and heavy Fluid on which the Crust subsided: but if it were so, it is certain that such a Fluid being heavier than water must have taken its place next to the Surface of the Earth, and have filled up all the pits, holes, and valleys that were on the Earth; nay it would have driven the Sea out of its Channel, and would have completely filled its place, where it would have remained to this day. It is most evident, that if such a thing had happened, there would have been vast quantities of that dense and heavy Fluid still abiding on the Surface of the Earth, and in pits and holes, there being nothing to drive it from thence into the Fissures again: But yet it is evident from Observations, that there is not any such thing in Nature to be seen, and that there is no
where

where to be found any quantity of such a dense and heavy Fluid, which Mr. *Whiston* supposes covered the Earth at the time of the Deluge. There is only a little Quick-silver which is found in some Mines in the very bowels of the Earth; but the quantity of it is so small and inconsiderable, that we cannot possibly suppose it to be the remains of the Fluid in the Abyss. For if ever there had been any such Fluid on the Surface of the Earth, there must have certainly remained greater quantities of it to this day, since as I have observed before, the very Seas must have been full of it.

I freely acknowledge Mr. *Whiston's* Hypothesis about Shells, Bones, Teeth, and other *Exuviae* of Land and Sea Animals, found and dug out of the Bowels of the Earth to be very Ingenious and more Philosophical than any other Hypothesis that I have yet seen; so that to me it seems indeed probable, that the water which made the Deluge from whence soever it was derived, had in it much Mud and Earthy matter; which after the waters were gone off, settled on the Surface of the old Earth, and became a new Crust; in which these Shells, Teeth, and Bones subsided. This Hypothesis I think, doth very naturally explain all the Phænomena Dr. *Woodward* mentions in his Theory, and on that account it may be easily admitted as a true one.

I come now to consider Mr. *Whiston's* way, by which he supposes all the waters, that were necessary for the Deluge, were drawn of the Earth. He imagins this to be performed partly by a wind which dried up some, and partly by the descent of the waters through the Cracks and Fissures of the Earth; to which the wind by hurrying the waters up and down would be very sufficient. Before I examin these causes, it is fit that I should make an estimate of the quantity of water, that would be necessary to cover the whole Earth above the tops of the highest Mountains. Dr. *Burnet* in his *Theory of the Earth*, reckons it to be about eight Oceans of water, supposing the Surface of the Sea to be equal to the Land, and to be every where a quarter of a Mile deep, taking one place with another. But on the same supposition, I believe, I can more exactly determin it to be near three times as much. I must here assume, that the height of the highest Mountain above the level of the Ocean, is above three Miles perpendicular height. I know *Varenius* in his *Geographia Generalis*, Calculates the height of the *Pico* in the Island of *Tenerife*, to be one *German* Mile, or above four *English* Miles in height: and tho' I am inclined to believe, that its height is yet greater than *Varenius* makes it (for he seems to allow too much, both for refraction and errors in the Observations;) yet because three Miles is the height,
Mr.

Mr. *Whiston* seems to allow the waters at the Deluge, I will suppose the Hills no higher; and from thence I will Calculate what water would be necessary to make an Universal Deluge.

It is evident, upon such a supposition, that the waters must be raised beyond three Miles perpendicular height that they may be as high as the tops of the Hills. Now it is easy to Calculate how much water would be necessary to raise the Surface of the Sea to such an height. The Ocean being by Hypothesis a quarter of a mile deep, there are twelve such quarters in three Miles, and consequently there must not be less than twelve Oceans of water lying on the Surface of the Sea, that it may be of the same height with the water which covered the Land.

Let me in the next place suppose the whole surface of the Land thickly beset with Mountains, every one of which was three Miles perpendicularly high: now because three Miles has but a very small proportion to the semidiameter of the Earth, it is evident, that the Orb, or rather part of an Orb, consisting of waters and Mountains, would be also equal to a Cylinder, whose height is three Miles, and its base a Circle equal to the Surface of the Land. But because the Hills are supposed to be of a conical Figure, and cones by the 10th of the 12th of *Euclid*, are the third part of a Cylinder on the same base and of the

the same height, it is evident that the Hills would make but one third part of the former Cylinder; that is, all the Mountains if they were levelled, would raise the Surface of the Earth a mile higher than it is: from thence it follows, that the water, which lay on the Surface of the Land at the time of the Deluge, was equal to a Cylinder, whose base was equal to the Surface of the Land, and its height two miles. And because in two miles there are eight quarters of one mile, it is plain, that the water, which was necessary to cover the Land, must be equal to eight Oceans of water; which together with the other twelve, makes twenty Oceans of water. But because the whole Land is not so thickly covered with Hills as I have supposed, (it being indeed not possible that it should be) and because there are but few Hills so high as I have supposed them all to be, we must at least allow two Oceans more on these two accounts: so that the whole amounts to two and twenty Oceans of water, which together with the water that doth now compose the present Ocean, makes three and twenty Oceans of water, which is the least that can be necessary for an Universal Deluge. If the height of the greatest hills were four miles above the Surface of the Ocean, as most probably it is by *Varenius's* Calculation, the water, that must be required to drown the whole Earth, must be no less than twenty
eight

eight Oceans of water. But I will here suppose there was no more water, than what was required by the former supposition.

Tho' it be easy for Mr. *Whiston* to suppose all this, or even a much greater quantity of water to be derived from the Atmosphere of a Comet; yet I believe he will not find it so easy a task to remove it again from the Earth. He himself acknowledges, that the Air could receive and sustain but very inconsiderable quantities of it in comparison of the entire Mass of waters, which then lay on the Earth. It is not possible, that this water could descend through the Cracks and Fissures of the Earth, which of necessity must have been all full at the time of the Deluge: for water cannot lye on the Surface of the Earth, till all the Cracks, Holes and Fissures in it be first filled. This is so evidently certain both to sense and experience, that I think it beyond all contradiction true; it being as impossible to make water lye on the Surface of the Earth, before all its Cracks, Pits, and Holes are filled, as it is to make a Vessel retain water, whose bottom is bored through with holes.

But tho' I should suppose that the Cracks and Fissures remained empty during the Deluge (which is indeed an impossible supposition;) yet it is certain, that these Fissures could receive but little more water than what was at first derived from them. For the
Crust

Crust of the Earth according to Mr. *Whiston*, lying immediately on the dense and heavy Abyſs, and water being lighter than it, it is absolutely impoſſible, that ever water ſhould ſettle it ſelf between the Cruſt and the Abyſs. It is therefore clear, that no more water could deſcend through the Cracks and Fiſſures of the Earth than what they were able to contain, or what had firſt aſcended through them to the ſurface of the Earth; which Mr. *Whiſton* ſuppoſes to be half the water neceſſary for making the Deluge, and muſt be according to the former Calculation, at leaſt eleven Oceans of water: Tho' indeed I cannot eaſily underſtand, how 'tis poſſible for them to contain and receive ſo much. What then can we imagin would become of the reſt? for after that the Channel of the Sea was compleatly filled, there would remain eleven Oceans more to be diſpoſed of; which there is no imaginable place in the Earth able to receive. And therefore it is clear even to a demonſtration, that all this water could never be removed by natural means.

THESE are the chief and moſt ſubſtantial points I have conſidered in Mr. *Whiſton's New Theory*; I might have made ſeveral objections againſt other parts of it, and particularly I might have taken notice of ſome miſtakes he has made in Geometry; but becauſe the Truth of his Theory doth not depend upon them, I have paſſed them over. If Mr. *Whiſton* will

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be pleased to make any answer to the Objections, I have here made; I would desire of him, that, whatsoever difficulties he designs to remove, he will do it by clear and distinct reasoning from Mechanical Principles. If he finds himself pressed with any objection, which he cannot answer, I doubt not, but that he will have the Ingenuity to own it. I know there are some Philosophers, that never miss to tell their Readers, they reason clearly and distinctly, when no body else can discover the consequence but themselves. And when they are so pressed with any difficulty, they make a long discourse about some thing the Reader knows not what, and endeavour to get off in a mist of words; but I expect no such dealing from one of *Mr. Whiston's* Candour and Sincerity.



AN
EXAMINATION
OF THE
REFLECTIONS
ON

The Theory of the Earth.

THE Defence of the Theory which has been lately Publish'd in Answer to my Examination of it is styl'd *Reflections on the Theory of the Earth*; But if its Author had observ'd the Title, and made more Reflections on the Theory, tho' fewer on the Examiner, he had acted more like a true Philosopher, and perhaps might have saved himself the labour of Publishing any thing more than an ingenious acknowledgment of its errors, and me the trouble of a Reply. But since the Reflector has been

pleased to follow another course, I must take his work, and consider it in the method it lyes.

He first sets down three propositions which He calls the foundation of the whole work, “*viz.* That the Primitive or Antediluvian Earth was of a different form from the present. 2^{dly.} That the face of the Earth as it rose from a *Chaos*, was smooth, regular, and uniform, without Mountains and Rocks, and without an open Sea. 3^{dly.} That the disruption of the Abyss or the dissolution of the Primeval Earth was the cause of the Universal Deluge. To these he adds a Corollary drawn from the primary propositions concerning the position of the Earth; in which he says, that the posture of the Antediluvian Earth or its Axis, was not oblique To THE AXIS OF THE SUN or of the Ecliptick as it is now; BUT LAY PARALLEL TO THE AXIS OF THE SUN, and perpendicular to the plane of the Ecliptick.” These he makes the only fundamental propositions of the Theory, (tho’ the Theorist in his ninth Chapter Book II. makes one more concerning the oval figure of the Earth) and tells us, “That he who will attack it to the purpose, must throw down in the first place these leading propositions, and that if the Examiner had taken this method, and confuted the proofs that are brought in confirmation
“ of

“ of each of them, he needed have done no
 “ more ; but if instead of this, a loose stone
 “ be only picked out here and there, or a
 “ Pinnacle struck off, it will not weaken the
 “ foundation.

I cannot imagine how this Author can assert that I have not followed this method in refuting the Theory ; for if these he has mentioned be the the substantial and vital parts, I have examined every one of them, as will plainly appear to any one, who will read the Examination ; so that what he has said of me in another case, may be very well apply'd to himself, *That either he never read over, or does not remember, or which is still worse, does willfully misrepresent what I have written on this subject.*

The design of the first Chapter of the Examination is not as this *Defender* imagines : to prove that the Deluge might have been made by a miracle, but to answer the general Argument which the *Theorist* with a boldness little becoming a Divine, brought for the truth of his Theory, viz. * that it could be * *English Theory Ch. 7. Book I.* made no other way, and therefore his method being the only way possible, was the real one. To this I answered, that I thought it possible the Deluge might come by a miracle, and that God Almighty was the immediate cause thereof, the Scriptures having given us such an account of it in these emphatical

terms, (Gen. 6. 17.) *Behold saith God, I even I, do bring a flood of waters upon the Earth.*

But the *Defender* is displeased because I did not tell him wherein this miracle consisted. The truth is, I never thought it my business to explain miracles; and I wish no *Theorists* or *Philosophers* had set up for it. I should be well contented to find in their writings a Mechanical and easy account of the common and ordinary Phænomena of nature. But it seems this Author will not be satisfy'd unless I tell him how the increase of waters at the time of the Deluge was made on the Earth. I answer, that according to the Scripture, some of the water was raised from the great deep, and sustain'd on the surface of the Earth by the hand of Omnipotence, a great part of it descended by forty days continual rain; the waters which occasion'd this rain being either newly created, or risen from other matter turned into that Element, or brought from some other place best known to the Divine Omniscience: which of all these three methods was used, I will not take upon me to determine; but I think it might have been done by any of them, notwithstanding the reasons alledg'd in the second and third Chapters of the Theory, which this Author thinks me oblig'd to answer. It seems he thinks them very strong and convincing, tho' when I wrote the Examination, I thought them

them so weak and precarious that it would not be worth while to take notice of them.

* The arguments against a Creation of waters * *English*
are founded on a notoriously false notion of *Theory Ch.*
the *Cartesian* Philosophy, viz. That matter *3. Book I.*
and space are the same: according to which principle 'tis not easy to understand, how either Creation or Annihilation can be possible. Nor do I think the arguments against Transmutation of Air or other bodies into water, of greater force than the former: For if all bodies be only different in their modifications, motions and figures, I can see no reason why any body may not be changed, and put on the form of another; and therefore, if according to the Theorists principle there is no vacuity in Nature, not only the Air may be changed into Water, but also all the subtil matter which fills its Pores; and according to this principle of a Plenum, that subtil matter will make as much Water as if the same bulk of absolutely solid matter were transformed.

The *Defender* alledges, that if I proceed upon such Waters as were already in being, and make them either Supercoelestial or Subterraneous, I must tell him WHAT THESE WATERS ARE, and must answer such objections as are brought against either sort in the second and third Chapters of the Theory; if he means that I should tell him the nature of this Water, and of what sort it was, I

answer, that it might be common Water, for that will be sufficient to drown the World; but if He designs that I should tell him from what place it was brought, and how it came there, I must own I know not: For to answer the question which he makes in another place, I have not yet been all over the Universe to make Observations, nor have I had any Revelation made me; it is enough both for him and me to suppose this Water like common Water, and that 'twas brought upon the Earth by the Power of God. The arguments which the *Theorist* brings against the possibility of any such Waters, are sufficiently answered in the 30th. and 31st. Pages of the Examination.

After this, the *Defender* passes to the second Chapter of the Examination, where I find he has but little to say to the arguments, tho' he would fain have them appear small and trivial. I affirm in that Chapter that most of those bodies which compos'd the outward Crust of the Earth were heavier than Water, and by consequence must descend both through the Oyl and Water also; and that tho' small grains of dust, specifically heavier than Oyl, if thrown upon it would not descend because of its tenacity, yet if the weight of these particles chanced to be increased by the additions of more, they must fall down. To this He makes answer, that the parts which formed the Crust were not
huge

huge lumps of solid matter, but little tenuious particles or small dust. Did not I make the same supposition, and yet shew'd that tho' these small particles of dust when they first fell, might have been sustain'd by the Oyl, yet when their bulk came to be increased by the falling of a great many others, their weight would be augmented proportionally; upon which account they must descend like other huge lumps of solid matter, and that long before ever they could form a solid Crust, that would be necessary to support the weight of all the rest of the descending particles? But the *Defender* has wisely passed over this part of the argument, knowing it would be a hard matter to answer it.

I wish the Theorist or his Defender would be so kind as to give us a specimen of this Operation for the making of an Earth, and because it wou'd be too hard a task to make a whole One, I would desire them to make a small portion of One; let them take a Vessel, in which let some Water be pour'd in, and after that some Oyl, and I would have them try if by throwing on the Oyl, small grains of Sand, Gravel, Clay, Stone, and other Materials heavier than Water, they can form a Crust: and we shall begin to think the rest of their Theory possible, if this Experiment succeeds.

I had another Objection against such a formation of the Crust, upon the consideration
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of the great height, from which these particles would fall, by which their force and celerity must be very much increased, and therefore of necessity they must pierce the oily liquid, and break thro' to the bottom; this the *Defender* allows of, providing these particles descended like stones or any other ponderous bodies; but He affirms these particles descended not in that manner, but rather like flakes of Snow hovering and playing in the Air, their course being often interrupted and diverted, and their force broken before they arriv'd at the end of their journey. To this I answer, that tho' these particles were small, yet they were ponderous, being of the same intrinsic gravity with the matter of which the outward Crust of the Earth is made up, and upon that account we cannot suppose them to be like flakes of Snow, whose weight is but small, and their surfaces very large in proportion to their bulk, which therefore must suffer a far greater resistance than we can suppose these descending particles to have done. Besides, if we consider the great height from whence these particles fell, which the *Theorist* affirms to be as high as the Moon; and the thinness of the Air at such a height (which must be extreamly pure when Mr. *Newton* calculates that now at a Semidimeters distance from the Earth; the Air is so rare, that one inch of our common Air near the surface, if so much expanded

expanded as that is, would fill a sphere as large as that of *Saturn*) we must of necessity think, that the descending particles would not meet with so great a resistance as the Defender imagines. For whatever interruption or diversion they met with from the Air in their descent, would be inconsiderable. But the greatest part of it would arise from their falling on other particles which were also descending, tho' not so fast, by which, tho' the velocity of the swiftest body would be diminished, yet according to the Laws of motion, the momentum or quantity of motion of both bodies taken together would remain the same, and by consequence their force upon the oily Orb would be also the same. I know no way the *Theorist* can take to answer these objections, but by supposing that the Creation was neither in Spring, Summer nor Autumn, as is commonly suppos'd; but that it was in the Winter when both the watry and oily Orbs were frozen, and had consistence enough to sustain these particles till they were formed into a solid Arch, able to sustain it self; and if he will embrace such an opinion, I shall not take the trouble of refuting it, having so many others of the same weight upon my hands. The Reader may observe, that He takes not the least notice of the argument I brought against him from Scripture, to prove that there were Metals in the primitive Earth, which he plainly denies.

After

After these things this Author comes to quarrel with me for making insinuations and suggestions, as if the *Theorist* did not own the hand of a particular and extraordinary providence in the formation of the Earth. I own I did make such insinuations, and I leave the Reader to judge whether I had not Reason to make them. He has openly rejected the History of the formation of the Earth as deliver'd by *Moses*, and has deduced it purely from natural causes, and the necessary Laws of Mechanism. Now if the matter of the Earth from a *Chaotick* state did of necessity form and settle it self into a habitable Earth, from the sole necessary principles of Mechanism and Gravitation, as the *Theorist* has deduced it; I would fain know how this opinion differs from the *Epicurean*, which the *Theorist* so deservedly derides? I know the *Theorist* talks very much of Providence both ordinary and extraordinary, and makes most excellent Discourses against the *Epicureans* for denying of it, which I was so far from not reading or forgetting, or even willfully misrepresenting, that I transcrib'd some of them in the Examination, as an argument against his own Theory.

It is a common thing with Theorists and Philosophers, who are great Politicians in their way, to disown any opinion which they think will bring upon them the displeasure of any considerable part of Mankind, tho' it follows

follows plainly from their Principles; or if that cannot be done, they hide and colour it the best way they can, that it may not appear too open and plain. Thus the *Theorist* protests, that he meant no harm, when he affirm'd the History of the Creation as it was deliver'd by *Moses*, to be fabulous, and ridicul'd the Scriptural relation of the Fall; and I have really the charity to believe him; yet hereby he has set the *Atheists* and *Theists* in a method of attacking our Religion, and given them Schemes by which they think they can defend their own Principles.

After this the *Defender* passes to consider what is said in the third Chapter of the Examination about Mountains; He owns it to be a subject that deserves consideration, and He says, that if the Examiner can prove that there were Mountains in the primitive Earth, He will undertake that the *Theorist* shall make no further defence of his Theory. The *Theorists* great argument why the face of the primitive Earth was smooth and without Mountains, depended on the supposition that the *Chaos* from whence it took its original, was perfectly a fluid Mass. This I affirm'd to be a precarious Hypothesis without any foundation in nature, since the greatest part of the bodies we have in the Earth, are hard and solid, and there not being a quantity of Water in Nature, sufficient enough to moisten and liquify them, the *Chaos* could not be so fluid
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as 'twas necessary it should be, to form it self into an uniform smooth body. Besides that, the greatest part of them, such as Stones and Metals, are incapable of being liquify'd by water. The Defender's reply to this is, *Very good, what is this to the Theory? Does the Theorist any where affirm that there were Stones or Metals in the Chaos, or that they were liquify'd by Water? The Theorist owns no such doctrine or supposition.* I hope the Defender will not think this any answer to the objection; I am sure none of his Readers can. I thought that it concern'd the Theorist very much, to prove his *Chaos* to be a fluid Mass of matter; for otherwise it is not necessary that it should have its surface smooth, regular and uniform; at least it is fitting that the objections against its fluidity should be answer'd. For if the Examiner can prove that the *Chaos* was not altogether so fluid as the Theorist imagines, and from thence shew, that there was no necessity that the face of the Earth should be smooth and without Mountains, then the *Theorist's* argument must be of little force, and that objection will still very much weaken the truth of the Theory.

I freely own indeed that the World was produced from a *Chaos*, such a one namely as is recorded to us in Scripture; but I am far from granting that the Theorist's notion is any ways agreeable to it, he supposes that all the Elements Air, Water and Earth, with all
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the principles of Terrestrial Bodies were reduc'd into one fluid Mass, and mingled with one another, so that the parts of any one sort could not be discern'd as distinct from the rest. This I suppose is a new sort of *Chaos* which never existed any where but in fancy.

It were easy for me here to assume the Defenders method, and argue against it, by putting him questions, how, when and where, was this mixing and blending together of all the Materials of Heaven and Earth? By whom, upon what design, and for what purpose was this done? Was it to the end that they might all settle themselves again in order, and each take its place, according to its specifick gravity; but if the great parts of the World were for the most part so before, what necessity was there for disturbing them, only that they might range themselves orderly again. He would do well also to tell us, from whence he had this account of the *Chaos*, from Sacred or Profane Writers, if from the latter, we are to value their authority no further than they are agreeable to the Scriptures, since it would be no hard task to prove, that it was from the Sacred History that the Heathen Writers first drew their knowledge of the *Chaos*, which they afterwards corrupted with their own fancies. In the Holy Scriptures I can find no account of the mixing and reducing of all the Materials
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of the World into one fluid Mass. *Moses* indeed tells us, that the Earth was *Toku* and *Bobu*, which we render without Form and Void, and can we from thence conclude, that all the parts of it were fluid and mixed together? We may allow, that the *Jews* understood the sense of these words better than we, or any Heathen Writers, and they give them a contrary meaning; for according to the *Syriack* Translation, those words signifie, that the Earth was without either Habitation or Cultivation, *Terra erat desertâ & inculta*; in the *Chaldaick* Paraphrase they signifie, *Deserta & vacua*. The *Targum* of *Jonathan B. Uziel*, supposes their meaning to be this, *Terra autem erat stupor & inanitas, vasta à filiis hominum & vacua ab omni jumento*; with which the *Jerusalem Targum* does well agree, according to which Paraphrase they signifie, that the Earth was *Stupor & inanitas & desolatio à filiis hominum, & omni bestia vacua*, as that Paraphrase is render'd in Latin. We may conclude from thence therefore, that the *Jews* thought that all that was mean't by the words *Toku* and *Bobu* was, that the Earth was Void and Uncultivated, without Ornaments and Inhabitants, Men or Beasts, or any sort of Animals.

Nor was the Opinion of the ancient Christian Fathers any wise different from that of the *Jews* as to this matter, *Tertullian* in his book against *Hermogenes* says, *Unde compertus es Hermogenes uniformem & inconditam illam fuisse materiam*

materiam quæ ut invisibilis latebat; and in the 30th. Chapter he plainly proves from Scripture, that there was not a confus'd heap of matter mixed and blended together, out of which all things were made. St. Ambrose in the 8th. Chapter of his *Hexameron* says, that the Earth was *incomposita utpote solertis agricolæ inarata culturis, quia adhuc deerat cultor*, and again, *Terra erat incomposita quia nuda gignentium, nec thoris herbosa riparum, nec opaca nemoribus, nec leta segetibus, nec umbrosa superciliis montium, nec odora floribus, nec grata vinetis.* * St. Basil tells us, that the true beauty and composition of the Earth arises from its great fertility, whereby it is productive of all sorts of Vegetables, such as Plants of all kinds, lofty and tall Trees, as well those that bear Fruit as those that afford us none, fragrant and sweet Flowers differing both in colour and smell; and the Earth says he, being naked and unfurnished with any of those sorts of Ornaments, might well be said by the Scriptures, to be Void and without Form.

In those discourses of the ancient Jews and primitive Fathers, there is not one word of a perfectly fluid Mass of matter out of which
O all

* Ἐστὶ μὲν ἐν τελείᾳ κατασκευῇ γῆς ἢ ἀπ' αὐτῆς ἐυ-
δηνία. φυτῶν παντοδαπῶν βλαστῆσεις, δένδρων ὑψηλοτά-
των προβολαί, καρπίμων τὲ καὶ ἀκάρπων, ἀνθῶν εὐχρησταί
καὶ εὐοδίαί, &c. ὧν ἐπειδὴ ἔδεν ἔπω ἦν, ἀκατασκεύασον
αὐτὴν ὁ λόγος εἰκότως ὠνόμασε. In his 2d. Homily in
Hexam. near the beginning.

all things were made, there is nothing there of the mixing and blending together of the Elements, and all the Materials of Heaven and Earth; in their Writings we cannot see that such a *Chaos* as the *Theorist* fancies, was ever either deliver'd or suppos'd: we find that their notion about the origination of the World was very different from the *Theorists*, whose Hypothesis is not therefore founded on any authority which is sufficient to induce us to believe it.

Nor has his opinion any more foundation in reason than authority, for if we should allow of the *Theorists* account of the Waters that are in the Earth and from thence by computation compare the solid bodies with those that are fluid, we shall find, that the liquids are not the hundred thousandth part of the solid bodies in the Earth; nay, if we should take in the Atmosphere, the whole System of fluids will not amount to the thousandth part of the solid bodies: from which it plainly appears, that the *Chaos* cannot be thought to have been in any manner an entirely fluid Mass, but rather a hard and solid one. For if we take hard bodies as Earth or Clay, and fluid as Water or Oyl, and mix them together in the proportion of eight thousand to one, or even in that of a thousand to one; that is, take one inch of fluid matter for a thousand inches of solid matter, the fluids will have but a very small effect on the solids. Since
therefore

therefore the whole composition of the *Chaos*, when all its parts were mixed and blended together, must not have been fluid, but rather hard and solid; I hope the *Defender* will allow the objection to be to the purpose, and of force against the Theory, which is founded on a contrary supposition.

Having thus prov'd that the far greatest part of those bodies which compos'd the *Chaos*, were firm and solid, I think it easie to shew, why there is no necessity that an Earth form'd from such a composition, should be smooth and regular; for it is not so with solids as with fluids, where all range themselves according to their intensive gravities, and settle themselves into a regular and even surface; whereas solids take their place according to the order they happen to be in, that body coming soonest to its rest, which is nearest the Centre, without any respect had to gravity or levity, and where these bodies happen'd to be thickest or highest, or their parts less coherent, there also after their fall would their surfaces be highest, and the face of the whole would be very rugged and mountainous; the liquids, if we should allow them to separate from the solids, would descend and fill the Holes, Cavities, and Caverns that were made by the falling of these irregular peices on one another, and what was more than sufficient for this, might spread its self upon the Valleys, and leave great protuberances

berances of the solid Mass, as great as any of our Mountains standing out above the surface of the Water.

But granting, that the greatest part of the *Chaos* was a fluid Mass, I brought another argument in the Examination to shew, how the face of the Earth might be mountainous and uneven, by supposing in the *Chaos* a great many bodies, which, by being in a great measure hollow, or fastned to some other matter of less gravity than that of the fluid *Chaos*, would swim on the surface of it, after the subsiding of all the rest, and some parts of them standing above the surface of the watery Orb, would form Mountains. The *Defender* answers this, as he does most other objections, by a question, *Who told me that these lumps of matter were hollow? Is not this precarious, or rather Chimerical and ridiculous?* I answer, I came to know this after the same manner, that the Theorist knew there were neither Mountains nor Seas in the Primitive Earth; if it be a precarious Hypothesis I cannot help it, but it is my comfort, that if every thing that's precarious be also Chimerical and ridiculous, I know whole Theories that will be so likewise.

After this he falls into a strain of very learned questions, What made those solid lumps hollow, when, or where, or how were their inward parts scoped out of them? I know none but *Theorists* that can give a
positive

positive answer to such nice questions; I am content to say, they might have been so order'd by God Almighty at first, for that very end that they might swim on the Abyfs: tho' another *Theorist* says, that the fluid Abyfs was much denser and heavier than the Mountains, and therefore they could not sink: and it is indifferent to me which of these answers he takes, or if he find out some other of his own, which he can easily do if he has a mind to it, that he will like better. It is enough for me to shew, that there is no necessity that an Earth arising from a *Chaos*, should have its surface smooth and uniform, as the *Theorist* pretends it must.

But this *Defender* thinks that it is my opinion, that Mountains were really form'd after this manner, and from thence he proceeds to collect, from my Principles and Concessions, that there could be no Sea in the Primitive Earth, and that an Orb of Earth must have been built over the Abyfs, and after all he concludes, that I have no good hand in making Mountains.

This way of writing would almost tempt me to believe, that he had never read over that Chapter which he pretends to answer; for by the reading of it, one may plainly see that it was not my design to settle this, or any other new Theory of my own, about the formation of Mountains; nay, I positively declar'd, that I thought *there were other principles*

*ciples concurring to the formation of Mountains, besides gravitation and the known laws of motion: my business was only to shew the weakness of the Theorist's arguments, and that an Earth arising from a Chaos, might have been uneven, rugged, and mountainous, notwithstanding he asserted, that it must necessarily form its self into a smooth, regular, and uniform Figure. For my part, I think it absolutely indifferent to the question, what way Mountains were made at the beginning of the World, whether by Mechanical causes, or by the immediate hand of God Almighty, or if by hollowing and making a channel for the Sea, the Earth was rais'd and laid upon the dry land to form Mountains; (which by the by, is not so ridiculous or so repugnant to Calculation, as the *Theorist* imagines) it was sufficient to my purpose to shew, that there was no necessity that the face of the Primitive Earth should be without Mountains.*

Having thus laid open the weakness of the *Theorist's* arguments, I endeavoured in the next place to shew, the great use and advantage that Mountains afforded to mankind: The *Theorist* asserted, that they did not consist of any proportion of parts, that is referable to any design, or which had the least footsteps of Art or Counsel. This I thought was a bold and ill grounded assertion, since it is certain, that they are so far from being placed upon the Earth without any design or contrivance,

contrivance, that they are justly reckon'd by the Philosophers, amongst the most useful, as well as the most stupendous parts of nature; without them we could have had no Rivers or Springs, which are things necessary to us, not only for our Commodious living, but for our very subsistence. One would think that this consideration was a sufficient argument to make us believe that Mountains were not great Ruins, or the rubbish of a broken World; but that they had been placed upon the Earth at the Creation, with a design that they might serve the Antediluvian World, with the same advantages and uses they afford us in the present One. For it is certain, that they had Rivers and Springs as well as we, which they could not have in a smooth Earth, where there were no Mountains; in which, Rivers were to have their origin, no upper and higher grounds from which the water was to descend on the face of the Earth.

Instead of answering the argument, He makes a long declamation against me for asserting that it is impossible to live without Rocks and Mountains. He accuses me for confining the Divine Omnipotence and Omniscience, to one single mode or fabrick of a World, and of thinking all the Planets cast in the same mould: Who (says he) ever observ'd Mountains and Rocks in *Jupiter*, or in the remains of *Saturn*? I answer, who but those that have observ'd Men or other Ani-

mals there, that must have Water and Rivers, as things necessary for their sustenance?

Tho' the *Defender* is very Eloquent and Witty on this Subject, quotes *Virgil* and *Cicero*, and complains much of the narrowness of some Mens Souls, yet I think I can make it appear, that this assertion, as I deliver'd it, was no limitation of either the Divine Omniscience or Omnipotence. None ever doubted but that God Almighty could make Men subsist without Mountains, Rivers, Water, Meat, or any other sustenance; but yet, one may boldly say without confining the Divine Power, that it is naturally impossible for such Creatures as we are, to live without those things; for our Natures and Constitutions require them; and he must be without doubt in a præternatural state that can live without them. The subject I was then handling was in Natural Philosophy, where we are not so much to consider what is absolutely possible or impossible for God Almighty to perform, as what is agreeable or contrary to the establish'd Laws and Rules of Nature. Thus it is naturally impossible that Men or other Animals of such Constitutions as we have, can live without fresh Water, Rivers and Springs; it is contrary to the natural order of things, that these should be without Mountains and Rocks, Upper and Lower grounds, for Water cannot naturally run upon an Horizontal Plain; and therefore we may rightly conclude,

clude, that where there are Men, there must be Mountains and Rivers, Upper and Lower grounds, and all other things necessary for life.

It is absolutely indifferent to me, what sort of mould the rest of the Planets are cast in, or what Inhabitants there are in *Jupiter*, *Saturn*, or *Mercury*, or if there are any in either of them, (which I am sure is more than he can prove) yet I would think it no hard matter to shew, that it is impossible for us Men, or other Animals of the same Nature and Constitution that we have, to subsist in either of these places. For *Saturn* being very near ten times further from the Sun than we, must have a hundred times less of his influence; and the distance of *Mercury* from the Sun, being but one third part of our distance, the heat of the Sun upon that Planet must be nine times greater than it is upon ours, (the action of the Sun upon any subject being always reciprocal to the square of its distance) both which extreams are by far too great to be endur'd by Creatures of our texture and frame of parts; and therefore we may rightly conclude, that whether they be mountainous and rocky, or have their surfaces smooth and even, yet it is impossible that they should be Habitable by us, or Creatures of our Constitution; tho' yet we know not but there may be some sort of Inhabitants in these Planets, whose frame and temper will suit with the nature

nature and position of their respective dwellings. Thus we generally account the places that are near either of the Poles uninhabitable, because no Men can dwell there; tho' it is certain, that Bears, and several other Animals, whose natures agree best with such a Climate, live in these places; and perhaps, if ever the *Theorists* Earth had existed out of his own imagination, it might have been furnished with some sort of Inhabitants, tho' it had been naturally impossible for men to have subsisted there.

'Tis somewhat hard that a Man cannot dissent from the *Theorist* and his opinions, without being taxed for narrowness of Spirit. But whatever the *Defender* may imagine, I am sure, there are some who esteem it as a sign of a weak and narrow Spirit, to believe easily any Hypothesis, without sufficient evidence of its being true; which cannot be produced by the *Theorist* in this point. For my part, I think *Virgil's* Shepherd, whom the *Defender* laughs at for not letting his imagination rove, to fancy things he had never either heard or seen, much wiser than some *Theorists*, *Philosophers*, and *Freethinkers*, who take the liberty to imagine and believe any thing, but that to which in all reason they ought to give a firm assent.

After a long declamation against confining the varieties of Providence to a narrow compass, (which I know none that do) the *De-*
fender

fender asserts, that my arguments run upon impossibilities; which he says is a nice Topick, that lies much out of our reach; and he thinks, that there may be Rivers without Mountains, notwithstanding my reasons. All that I can say to this is, that if he will not be convinced by reasons, which he cannot or does not pretend to answer, he may think as he pleases; but I hope he will allow me the freedom to dissent from him, till those arguments be answer'd.

The design of the 4th Chapter, was to shew the inconveniences that would fall upon the Earth, in case it had such a posture as the *Theorist* assign'd the Antediluvian World, namely an Axis perpendicular to the plane of its Orbit. To this Chapter the *Defender* makes some general answers; but first, according to his usual custom puts a question, viz. If I will vouch that there are no habitable Planets in the Universe that have such a posture? *Jupiter* he says, is known to have a perpetual Equinox, and his Axis parallel to the Axis of the Ecliptick; here he is mistaken, for it is not parallel to the Axis of the Ecliptick, but that of its own Orbit; *Mars* says he, has little or no obliquity, and must we suppose that these Planets have no Inhabitants, or that their habitations are very bad and incommodious? *Jupiter* is the noblest Planet in the Heavens, whether we consider its magnitude, or the number of its attendants; and if a Planet of that order
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and dignity have such a position to the Sun, why might not our Earth have had the same? What is all this to the purpose? Are the Inhabitants of *Jupiter* the same with the Inhabitants of our Earth? Or how does he know that there are any at all there? It seems this Gentleman is mightily in love with *Jupiter* and its Inhabitants; what degree of nobility and dignity it has obtain'd I know not, yet if he was in the most pleasant country house in all *Jupiter*, so far I dare vouch, that he would not be pleas'd with his habitation, but would desire to change and come down again to his old Rocky Mountainous Planet the Earth, and rather than stay there, he would be contented to live in *Lapland*.

I make no question, but that the present position of *Jupiter* is very fit and well suited to the nature and temper of its Inhabitants, Plants, and Vegetables, (if there be any there) but what is fitting and commodious for them, may be very inconvenient for us; if we were in *Jupiter*, our blood perhaps would stagnate and freeze, and a Jovian if he were brought hither, would melt with heat. The inconveniences I shew'd, would arise from a perpendicular position of the Earths Axis to its Orbit, were only in respect of the Inhabitants of the Earth, and did not in the least concern those of *Jupiter* or *Mars*, to whom such a posture might be more convenient than any other. *Conveniencies* and *inconveniencies* are
relative

relative terms, and therefore to prove a position incommodious, we must not only consider the consequences of the position its self, but the Nature and Constitution of those Animals to which it is to be adapted; and I hope I may affirm (without any reflection on Divine Providence) that the present position in which God hath put the Earth, is more suitable and agreeable to the Nature and Frame of our Animals and Plants, than any other, and especially than that which the *Theorist* assigns to the Primitive Earth: I am sure that several Divines have asserted this, and were never thought by such an assertion, to prescribe to God Almighty what was best to be done.

I censur'd the *Theorist* indeed for enquiring into Physical causes, when there are none that can be known, and neglecting the final ones, which were the only real principles by which the question was to be determin'd. For as I shew'd in the Examination, there is no reason that can be assign'd why the Axis of the Earth should have one position more than another; the two motions of the Earth round the Sun, and round its own Axis, being perfectly independent on one another. God Almighty would order that which was most fitting and convenient for its Inhabitants; and I lay'd it down as an Axiom, that God Almighty did always choose such positions as brought with them the greatest good and advantage

vantage to the Universe; and therefore, since the oblique posture of the Earths Axis was that which its Maker was pleas'd to choose, I thought it might be undoubtedly presum'd, that it was the best. Proceeding on this principle, I enquir'd into the several advantages which we reaped by the present oblique position, and shew'd, that it was preferable to any other; and surely this cannot be (as the *Defender* thinks) a prescribing to God Almighty, and telling him what is best to be done in this or that World. When from the Wisdom and contrivance of what is already done, we argue that it could not have been done in a better manner.

He goes on and says, "That some men
 " cry out mightily against reason; and yet
 " none are more fond of it than they, when
 " they can get it on their side. Some men
 " inveigh against Physical causes, when o-
 " thers use them, and yet as gladly as any
 " make use of them, when they can make
 " them serve their purpose; and when they
 " cannot reach them, they despise them, and
 " are all for final causes." I never knew any
 that cry'd down either reason or Physical
 causes, when they were plain and obvious.
 But it is no wonder if there are some that are
 displeased with the reasons and causes that are
 assign'd, by a set of Philosophers who think
 they can give a Mechanical account, how an
 Animal, a Mountain, a Planet, or a World
 may

may be made; and yet they know not so much of the principles of Staticks and Geometry, as to explain the most common and ordinary appearances of nature, which are really explicable by Mechanical principles.

And tho' one would think that it were but reasonable, that a man who pretends to give the Physical causes of all those things, should be very well skill'd in Arithmetick, Geometry, Mechanicks, and the Laws of motion; yet it generally happens, that those that are least acquainted with those Sciences, pretend most to the solution of such intricate problems, whereas they, who know them best, can best discover how far they may proceed upon Physical causes, how far their principles will lead them in the discovery of truth, and where it is that they must be content to be ignorant; they know that they have not sufficient *Data* to determine such problems, nor a great many others that have not the hundredth part of the difficulty of those I have mentioned; and they are well pleas'd if they know their final causes, the uses for which they were design'd by their wise Contriver, and never trouble themselves with that which it is impossible to discover.

Monfieur *Hugens* I think, was at least as great a Philosopher as the *Theorist*, and it may be easily suppos'd, that he understood Mechanism somewhat better; yet he says, that he would be contented, and should think, that
he

he had done a great matter if he could come to the knowledge of things as they are now, never troubling himself about their beginning, or how they were made, knowing that to be out of the reach of humane knowledge, or even conjecture. *

* *Hugenii Cosmotheoros.*

This Author it seems is very angry with me, for denying, that the Primitive Earth had such a position as the *Theorist* assign'd it; and upon that account he says, I follow the very doctrine of those Scoffers mention'd by St. Peter, who said, *Since the Fathers fell asleep, all things continue as they were.* Why so? Did these Scoffers assert, that the Earth had never any perpendicular position to the Plane of the Ecliptick? and did St. Peter affirm the contrary? Did he say that the old World had a perpetual Equinox, the Equator being coincident with the Ecliptick, and its Axis parallel to the Axis of the Sun, as this Gentleman phrases it? I can find no such discourse in either of his Epistles, nor can I see how such a thing can be deduced from them.

A man that had no Theory, or any particular System of his own to defend, would think this the plain meaning of St. Peter, that there were some men then in being, that deny'd a Providence, or that God Almighty had any care in the Government of the World, because they thought, that since its Creation, every thing went on still in the same method, without any particular manifestation

festation of a Providence; these the Apostle refutes, by telling them, that the World once perished by a Deluge of Waters, and that it was to perish again by Fire; both which are arguments enough for a Providence, and of God's particular care of the World: this I take to be his plain meaning; except *St. Peter* be to be understood in an Allegorical sense as well as *Moses*.

After this general discourse, he comes to a more particular consideration of the inconveniencies alledg'd against the parallelism of the Axis of the Earth, with the Axis of the Ecliptick. One argument I brought was, that by the present position of the Earths Axis, we receiv'd more of the Suns heat, than if it had mov'd always in the Equator; and if our heat at present is not too great for us, (as without doubt it is not) it was a very good reason why the present position should be esteem'd better than that the *Theorist* calls a right one, wherein we should not have so much of the Suns influence, as we have. The *Defender* thinks this is no argument against the Theory, for says he, if the heat was equal and moderate in the temperate and habitable Climates, who would desire the extream heats of Summer? I answer, every one that observes how necessary the Summers heat is to the production of Vegetables, and the ripening of their seed, which could never be brought to any perfection,
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did

did the Sun shine always in the Equator, whereby the action of the Sun in our Latitude, would be little more than half of what it is at present in a Summers day, which therefore could never be sufficient for the growth and perfection of Vegetables. *But* (says he) *how does this appear, supposing the heat constant? Are there no Vegetables in Jupiter which has still the position the Theorist gave the Primitive Earth, and which is vastly further distant from the Sun, and by consequence must have much less of his heat?* Whether there are Vegetables in *Jupiter*, neither the *Theorist* nor I can determine, for we were never there to see, and I believe it was never revealed to him or any body else, that there are.

But supposing there are vegetables there, what is that to us? Does he think them of the same nature and texture of parts that ours are of? Or that ours, if they were transplanted thither could grow and ripen in such a cold soil, when it is certain, that they require at least twenty five times a greater heat or influence from the Sun, than is in that Planet? Besides, it is requisite (as I shew'd in the Examination) that our plants and vegetables should have very different degrees of heat, and therefore there must be such changes and alterations in the seasons, as are necessary to produce the design'd effect; for that heat which is requir'd for the first growth and vegetation of a plant, will not be
sufficient

sufficient for the ripening and perfecting of the seed thereof, and that which is necessary for the bringing the seed to perfection would quite wither the green and tender herb; and therefore, since this variety of seasons and alterations of heat, cannot be obtain'd either in *Jupiter* or in the *Theorist's* Antediluvian Earth; it is plain, that our plants could never have been brought to perfection in either of those places.

But it seems this *Defender* is of the opinion, that the plants and vegetables of the Primitive Earth, were of a different nature and constitution from those we have now; so that he must think, that the nature of all our plants was perfectly alter'd and chang'd, or that God Almighty having destroy'd the old, was pleas'd to give us a quite new species of vegetables and plants; this is a miracle that is recorded no where in Scripture, or any where else that I know of, and I hope he will not think us oblig'd, on his word to believe it.

I affirm'd also, that if the Earth had such a position as the *Theorist* assign'd it, that the greatest part of it wou'd not be habitable. For he himself acknowledges, that the Torrid Zone was uninhabitable in that Earth; and I am sure, that the greatest part of the two temperate Zones would not have sufficient heat to ripen their Corn and Fruits, and consequently would be nothing else but a Desert. To this he replies with this question, *How*

much less habitable would it be than the present Earth, where the open Sea which was not then, takes up half its surface? I answer, that upon the same consideration I cannot see how any part of it should be habitable; for there being no open Sea, whose surface is expos'd to the heat of the Sun, I cannot imagine how there could be vapours enough drawn up to furnish the Earth with Waters, Dews, and Mists. For when it is requisite that one half of the Earths surface should be cover'd with water, on purpose to furnish vapours enough for Rain and Rivers, how can it be supply'd if there were no Sea at all? Can any Man suppose that the Sun acted as freely thro' a Crust of an immense thickness to raise vapours, as it does now upon the surface of the open Sea? This by the way, I think is a very good argument against the *Theorist*, who asserted, that the Primitive Earth had no Sea.

But the *Defender* thinks, that it would be very hard, if the seasons of the Year were the same as they are now; that the Inhabitants of the Earth should be confin'd to Herbs, Fruits and Water, especially in the colder Climates, where the Winters are so long, and the cold vehement; this he thinks, would be a most unmerciful imposition. Really as hard and unmerciful as it is, there are a very considerable number of people in these cold Countries, the greatest part of whose Food, is Bread, Herbs, Roots, Milk,

Milk, Cheese, and the like; and who seldom tast any Flesh-meats. And why might not the *Antediluvians* lead the same kind of life? I cannot see that the imposition is harder upon one than the other.

The *Defender* says, that the change of the position of the Earth's Axis, is matter of fact, and must be prov'd from History. And he wishes the Examiner would consult Antiquity, which would give him a more favourable opinion of the Theory as to this point. One would imagine by this, that this Gentleman had the Observations of some Antediluvian Astronomers to produce, who had found, that the inclination of the Earths Axis was chang'd from a perpendicular, into the present oblique posture: But instead of those, he only quotes some Philosophers, that did not live within some thousands of Years of the time, when this change was suppos'd to be made. What credit is there to be given to such a Tradition? Can we imagine, that there can be any thing certainly known from Authors that liv'd so long after the time of this change? Especially, when these men have said a thousand other things, that neither the *Theorist* nor any body else can believe? And yet, if we consider what they have said, we shall find it but very little to his purpose.

Diogenes, Anaxagoras, Empedocles and Leucippus, talked of the inclination, declination, or depression of the World towards the

* Pages
66, 67,
68.

South, so that the Northern parts were rais'd higher, while the opposite parts slid towards the South. We may easily observe, that these Philosophers from their way of speaking, were no great Astronomers; it is hard to guess what they mean't by such sentences: But if we should take their meaning as the words at first seem to import, that one Pole of the Earth was more depressed, or inclined towards the Sun or the Ecliptick, than the other; the thing is absolutely false, for both the Poles are equally inclined to the Sun, or the Plane of the Ecliptick: (as I have sufficiently shew'n in the Examination *) But whatever their meaning may be, I am sure, it is easier to draw any other consequence, than that which the *Theorist* has deduced from their words; nay it is probable, that they mean't the direct contrary to what he says they did, namely, that the Sun formerly came more towards the North, than it does at present, and that its distance from them towards the South, is now greater than it was at first. This, one may easily deduce from the words of *Leucippus* as they are quoted by *Plutarch*, Λευκίππος παρεκπεσεῖν τὴν γῆν εἰς τὰ μεσεμβρινὰ μέρη διὰ τὴν ἐν τοῖς μεσεμβρινοῖς ἀραιότητα αὐτῆς δὴ πεπηγότων τῶν βορείων διὰ τὸ καταψύχθαι τοῖς κρυμοῖς, τὴν δὲ ἀντιθέτων πεπυρωμένων. *Leucippus terram in partes austrinas prolabi putat ob istarum raritatem, quippe gelu concretis partibus Septentrionalibus, dum oppositæ interim ardent.* So that it seems

seems according to *Leucippus*, the Sun acted more strongly upon the Northern Hemisphere formerly, than it does now, and that it does not now come so near the Zenith of those that live towards the North-Pole, as it did at first; whereby the waters of these Northern parts are quite frozen and turn'd into Ice, while the parts toward the South, (being on the contrary expos'd to too great heat) are burnt and scorch't: that is, the declination of the Ecliptick from the Equator (at least toward the North) was greater formerly than now.

Thus, we see how little favourable these Philosophers are to the *Theorist's* opinion; and that their sentiments are at least as capable of being brought as arguments against him as for him.

It is true, that *Plato* speaks of ἀναρμονία καὶ ἀνομολία, a disharmony or irregularity in the motions of the Heavens, that was not under the reign of *Saturn*. But this signifies nothing to the *Theorist's* purpose; for if we should admit of his position, yet still there would be the same apparent irregularities in the motions of the Heavens. For the Planets would not in that case move uniformly round the Earth, but would have their directions, stations, and retrogradations, as they have at present; and none of them but the Sun would move precisely in the Equator. The other quotation the *Theorist* brings from *Plato*, is nothing to

his purpose, and is alledg'd by another *Theorist*, to prove a quite contrary Hypothesis.

These are the testimonies the *Theorist* has produced from the old Philosophers, to prove the truth of his Hypothesis, which in my mind, if it were not for pomp and show, he might have as well let alone; for I think, they will prove any thing else just as well as what he design'd. If these Gentlemen had spoke of a coincidence that was at first between the Equator and the Ecliptick, or of the Axis of the Earth or World, being perpendicular to the Ecliptick, or if they had said, that the Sun at first mov'd always in the Equator, or that the days and nights throughout the whole Year were equal, (which might have been easily said and much easier understood, than what they have deliver'd) they had spoke something to his purpose; but instead of this, we have some dark sentences, whose real meaning it is hard to guess at, and some of which seem to be so far from proving the *Theorists* position, that they seem rather to infer the contrary, and that the Sun's declination was greater formerly than now. Sure a man must be put to a hard shift for ancient Traditions, that will bring such Testimonies to prove his point.

But the *Defender* alledges, that these places will at least prove that there was some change made in the state of nature formerly; and if I will not allow that which the *Theorist* has assign'd,

assign'd, I must shew some other which will have the same effects. Why so? I hope he does not suppose me to be like some Philosophers, that think themselves oblig'd to give an account of every appearance, and fancy it a stain in their reputation and honour, to be ignorant in any thing: If he supposes such a thing, I assure him he is much mistaken; for I am sensible that there are more things which neither he nor I know than what we do. The Poets are the next witnesses the *Theorist* produces to prove the truth of his position: And these indeed talk of the continual spring and verdure of the Earth that was under the reign of *Saturn*. We know the Fable of the four Ages, of which the Golden was the first and best; in it they fancy'd every thing that was pleasant and delightful, and therefore they remov'd from it all extremities of heat and cold; and upon that account they would allow neither of Summer or Winter, but a perpetual Spring wherein every thing was fresh and blooming. But it is easie to perceive that all this was a figment: For when they or other Writers were to describe any pleasant places, they continually endow'd them with such qualities. Thus *Homer* describes the *Elysian Fields* as he is quoted by the *Theorist*, *Archæol. pag. 263.* and *Virgil* supposes that there were fine green Meadows there. This Poet also in summing up the praises of *Italy* and preferring it before all other Countries,

tries, among other excellent qualities he endows it with a perpetual Spring,

Hic ver assiduum atque alienis mensibus æstas.

Virg. Georg. Lib. II.

Thus *Plutarch* describes the fortunate Islands, and *Pliny* the *Loca Hyperborea*. From which we may clearly see, that there was no other foundation for any such assertion, but the fancy of the contrivers, who were to set forth their places of happiness to the best advantage.

But the *Defender* thinks, that if none of those he has mention'd will pass for sufficient witnesses of the matter of fact; yet I will certainly allow of the Testimonies of some ancient Astronomers, who have said something relating to this matter. Well, let us see what they say. He quotes *Baptista Mantuanus* from the *Archæolog.* whose words are these. *Erant illis (nempe Antediluvianis) ut Astronomiâ & experimento constat, Cæli propitiores; volunt namque Astronomi duos esse Zodiacos, unum in nona sphaera, alterum in octava, quod firmamentum vocant; & initio rerum & temporum sic à Deo dispositos ut Aries Arieti, Taurus Tauro, Gemini Geminis jungeretur, & amborum coeuntibus in unum viribus fortior fiebat in terris influxus, unde & herbas tunc salubriores, & fructus terræ meliores.* As also *Petrus Aponensis* in his *Conciliator Diff.* has these words, *Cum capita Zodiaci mobilis & immobilis ordinate & directe concurrebant, tum virtus perfectiori modo, à primo principio*

principio per medias causas taliter ordinatas fortiori modo imprimebatur in ista inferiora, cum causæ tunc sibi invicem correspondebant.

These Testimonies I own do sufficiently convince me, not that the *Theurist's* position of the Primitive Earth was the true one; but that the *Defender* who has alledg'd them to prove his point does not understand them. For he could not have quoted any thing that was less to his purpose than they are. I know not what skill this Author has in the new Astronomy; but I am sure he does not understand it if it be put into an old fashion'd dress. No doubt he thought that these Authors mean't by such words that at first the Equator and Ecliptick were coincident; when they never dream't of any such thing.

They as their own words informs us, suppose with all the old Astronomers two Zodiacks, the one of which is exactly placed under the other, and (the uppermost being immoveable) the lowest in which the fixed Stars are placed moves exactly under it, and performs its course from West to East, according to some in the space of 25000 Years. At first these two Circles had the same beginning, the Constellation *Aries* being exactly in the sign of the Ecliptick of the same name, and the Constellation *Taurus* was exactly in the sign *Taurus*; the Stars also that make up the figure of *Gemini*, were exactly under the sign *Gemini* of the immoveable Zodiack, and
so

so in the rest. By which these Astrological Gentlemen thought, that both their forces being united, their efficacy and vertue upon the Earth would be very strong. But now that the moveable Zodiack has mov'd, these two Circles have not the same beginning, and the Stars that make up the figure of *Aries*, are not in the sign *Aries* but in *Taurus*, and those Stars which compose the sign of *Taurus*, are no more in *Taurus* but in *Gemini*, so the Stars of *Gemini* are got into *Cancer*, and those of *Cancer* into *Leo*, &c. as may plainly be seen on any Cœlestial Globe. Which they suppose to be perform'd by the motion of the eighth Sphere or the moveable Zodiack, of which all the old Astronomers speak, whom if he pleases he may consult; particularly he may read *Clavius's* Notes on *Sacroboſco de Sphæra*, which is as common and as good a Book as he can find on the subject.

But it seems the *Defender* thinks that this would appear more to his purpose, if the old fashion'd disguise were taken off, and the business apply'd to the true System of the Heavens. Well let us see if it is so. The new Astronomers suppose that the Stars are immoveable, and that the Earth turns round the Sun, so that its Axis makes always the acute Angle of $66\frac{1}{2}^{\circ}$ with the Plane of its Orbit: if this Axis were perfectly directed to the same point of the Heavens, or mov'd always precisely

cifely parallel to its felf, then the fixed Stars would feem to have no other motion but the diurnal: But becaufe the Earths Axis varies a little from an exact parallelifm, and does not precifely point to the fame Star when it is in the fame place of its Orbit but makes a fmall Angle with a line that obtains the pofition it had formerly in the fame place; hence it happens that the Equinoctial points or the common fection of the Equator and the Ecliptick, retrocede or move backwards from Eaft to Weft; and this is that which the Astronomers call the preceffion of the Equinox, by which the fixed Stars feem to move from the Weft to the Eaft with a very flow motion, and the Conftellation *Aries* which at firft was in the fign *Aries*, has now got into *Taurus*, and *Taurus* has feem'd to move into *Gemini*, *Gemini* into *Cancer*, &c. From hence it appears, that according either to the old or new Astronomers, the fixed Stars change their Longitude daily but not their Latitude, and they have always fuppos'd that the Axis of the World has kept ftill the fame Angle with the Plane of the Ecliptick. I will now leave it to any indifferent Reader, or even to the *Theorift* and his *Defender* to judge, if thefe quotations fignify any thing to the purpofe, or if they are not ftronger arguments againft the *Theorift's* pofition than for it.

Since the *Defender* has advis'd me to confult Antiquity, I fuppofe it will not be amifs

to alledge the testimony of a very ancient Philosopher, whose authority ought at least to be as great as *Leucippus's*, *Anaxagoras's*, *Empedocles's*, or even *Plato's* I mean the Divinely inspir'd *Moses*, who is the most ancient Writer that is now extant, and the only one who gives us an account of the state and condition of the Primitive World, of which the Philosophers adduced by the *Theorist* were altogether ignorant; in his Writings there is not one word of the coincidence of the Ecliptick and the Equator, or of the perpetual Equinox and Spring that was observ'd in the Primitive Earth. *Moses* supposes no such thing but rather the contrary, for in giving an account of the Creation he tells us, that *God said let there be lights in the firmament of the Heavens to divide the day from the night, and let them be for signs and for seasons, and for days, and for years*; and from this it is observable, that *Moses* supposes that there were different seasons from the very Creation, and that their variety proceeded from the different motion of the Heavenly bodies, and more particularly of the Sun, whereas if the *Theorist's* Hypothesis had been true, the motion of the Sun could have made no variety of seasons; but the Year would have remain'd with the same face and tenour, having but one continued season. Thus it is evident, that the *Theorists* supposition in this matter, is directly contrary to that of *Moses*, and I think that his testimony

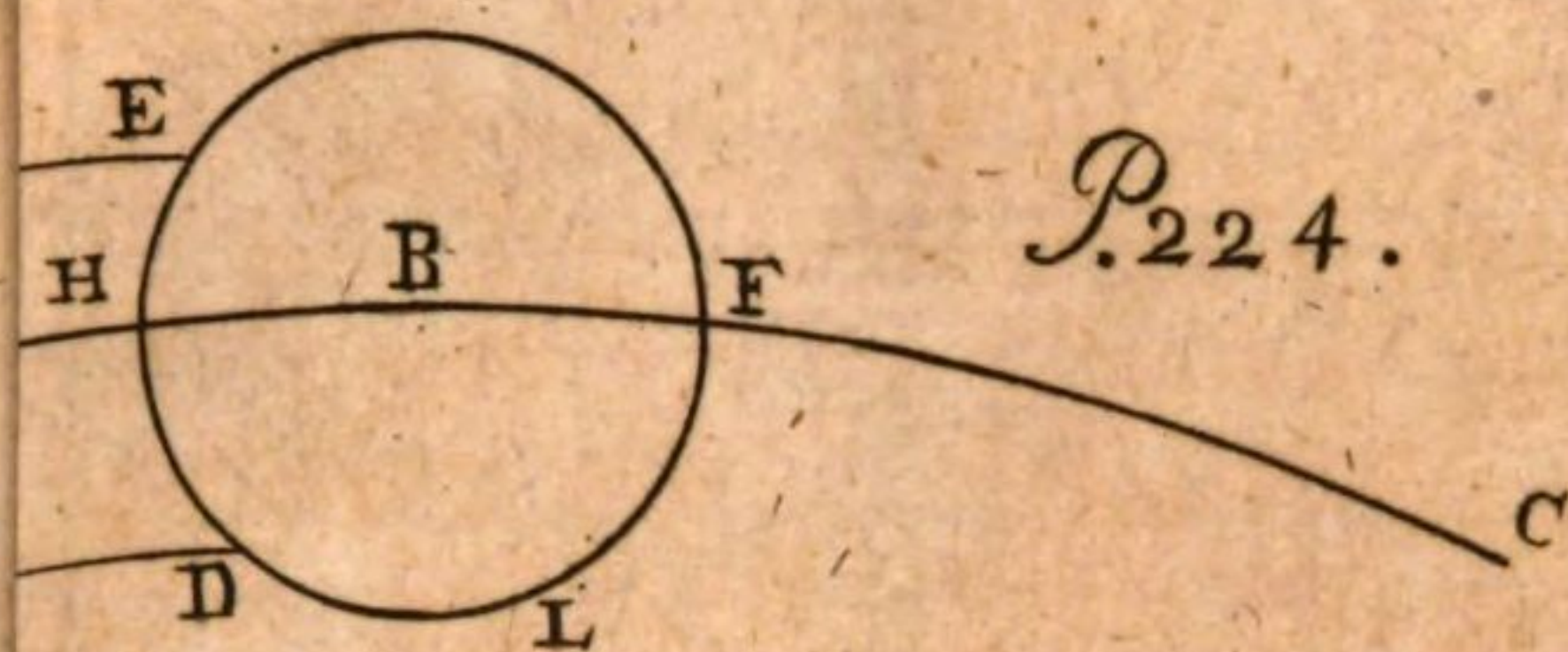
mony ought to be of greater force with any candid Reader, even supposing that he had no Divine Inspiration, than any thing that could have been said by such Philosophers as the *Theorist* has brought, who lived not till many hundred years after *Moses's* time.

After this dispute about matter of fact, our Author comes to defend the *Theorist's* reason he gave for the Antediluvian position of the Earth. It is said in the Theory, that the Earth being an uniform and regular Body, having its Center of Gravity the same with its Center of Magnitude, it would naturally take an even and parallel position with the Axis of its Orbit. In reply to this I told him, that it was demonstrated by the Writers of *Hydrostatics*, that a Sphere (or indeed any other body) whose Center of Gravity coincides with its Center of Magnitude, if put in a fluid of the same intensive Gravity with its self, will be indifferent to any position given. Our *Defender's* answer to this, is, *That such a thing may be*, that is, for ought that he knows it may be so, *if the Sphere was resting; but if it was turned about its Axis and the Axis of the fluid, it would certainly take a position parallel to the Axis of the fluid.* I wonder who assur'd him of this; I can scarce believe he had any Letters from *Kensington* or any where else for it; otherwise he would have produced them as the grounds of his certainty. Well, tho' he is very sure of his point, yet perhaps it
may

may not be true, and therefore we will enquire if it is so or not. [*Fig. 12. Plate VI.*] Let $A B C$ represent an Arch of the Ecliptick, or of any Circle parallel to it; $D E F$ any Circle in the Earth lesser or greater in the same Plane with the Circle $A B C$, let H be the point where the stream of the fluid falls perpendicularly upon the Circle $D H E F$ and take any two Arches $D H$ and $E H$ equal. The direction of the particles of the fluid falling upon the point E is $G E$, and of those which fall upon D is $I D$, so that the lines $G E$, $A H$, and $I D$, are parallel. Because the particles which move from G to E come obliquely on the point E , part of their force will be spent in carrying or driving the Circle forward, and part of it will be employ'd in turning the Circle round an Axis perpendicular to the Plane $A B C$ from H , to E and F . So that the total force of the particles is to that part of it which is used in turning the Circle round, as the square of the Radius to the Rectangle, contain'd between the Sine of the Arch $H E$ and its Cosine; after the same manner part of the force of the particles which move from I to D and fall upon the point D will be spent in turning the Circle round from $H D$ to L , so that the total force of the particles which rush upon D will be to the force by which they endeavour to turn the Circle round as the square of the Radius is to the Rectangle contain'd between the

the

Plate VI.



P.236.

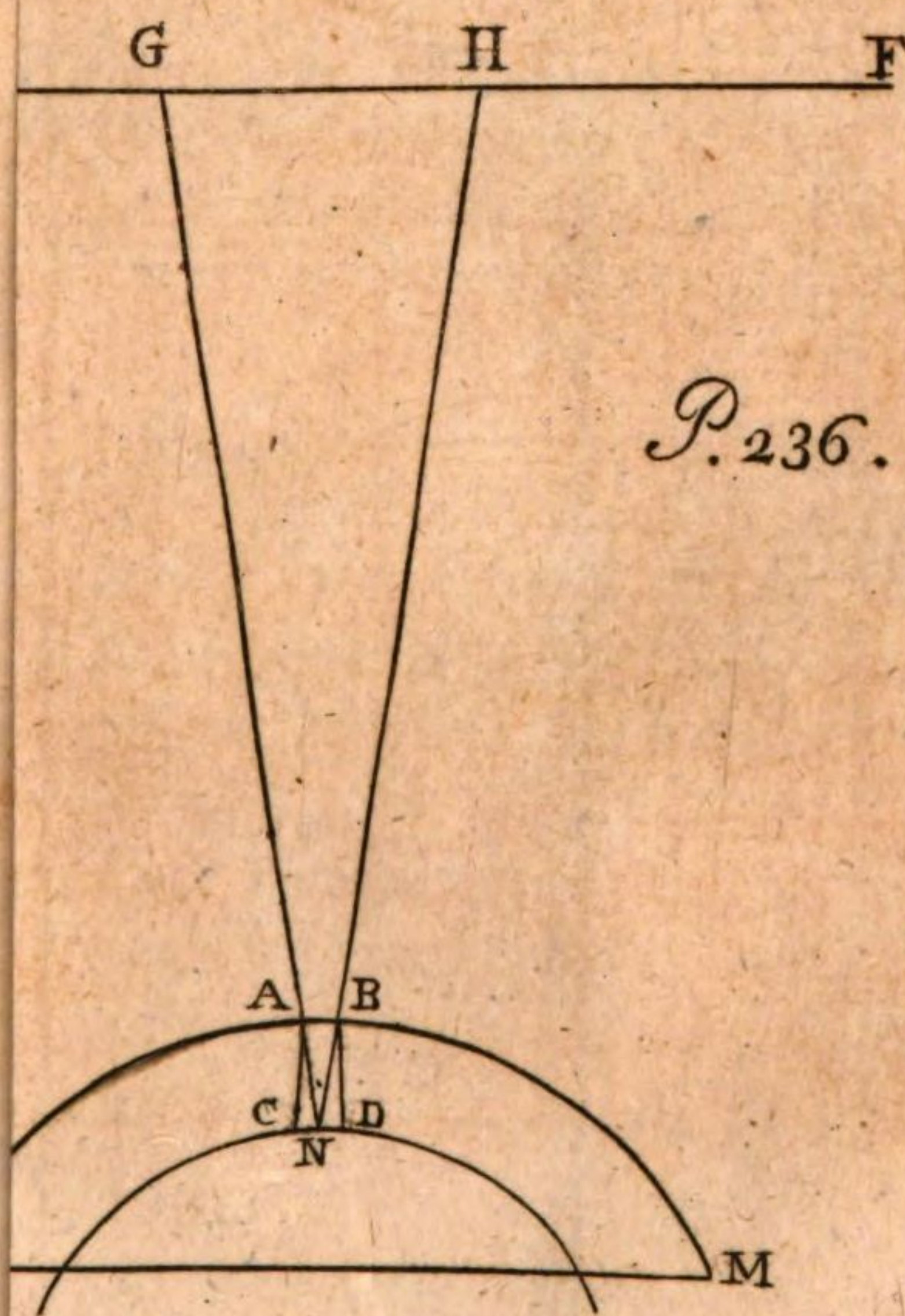
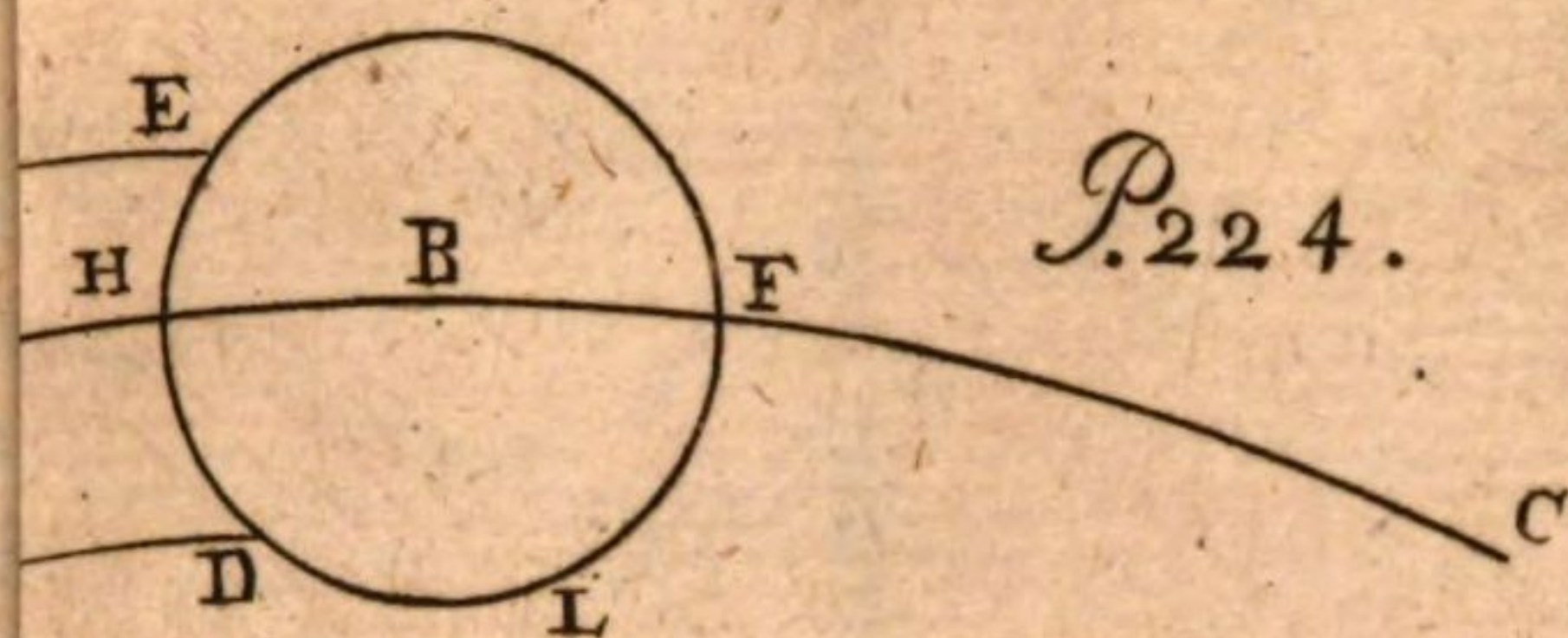
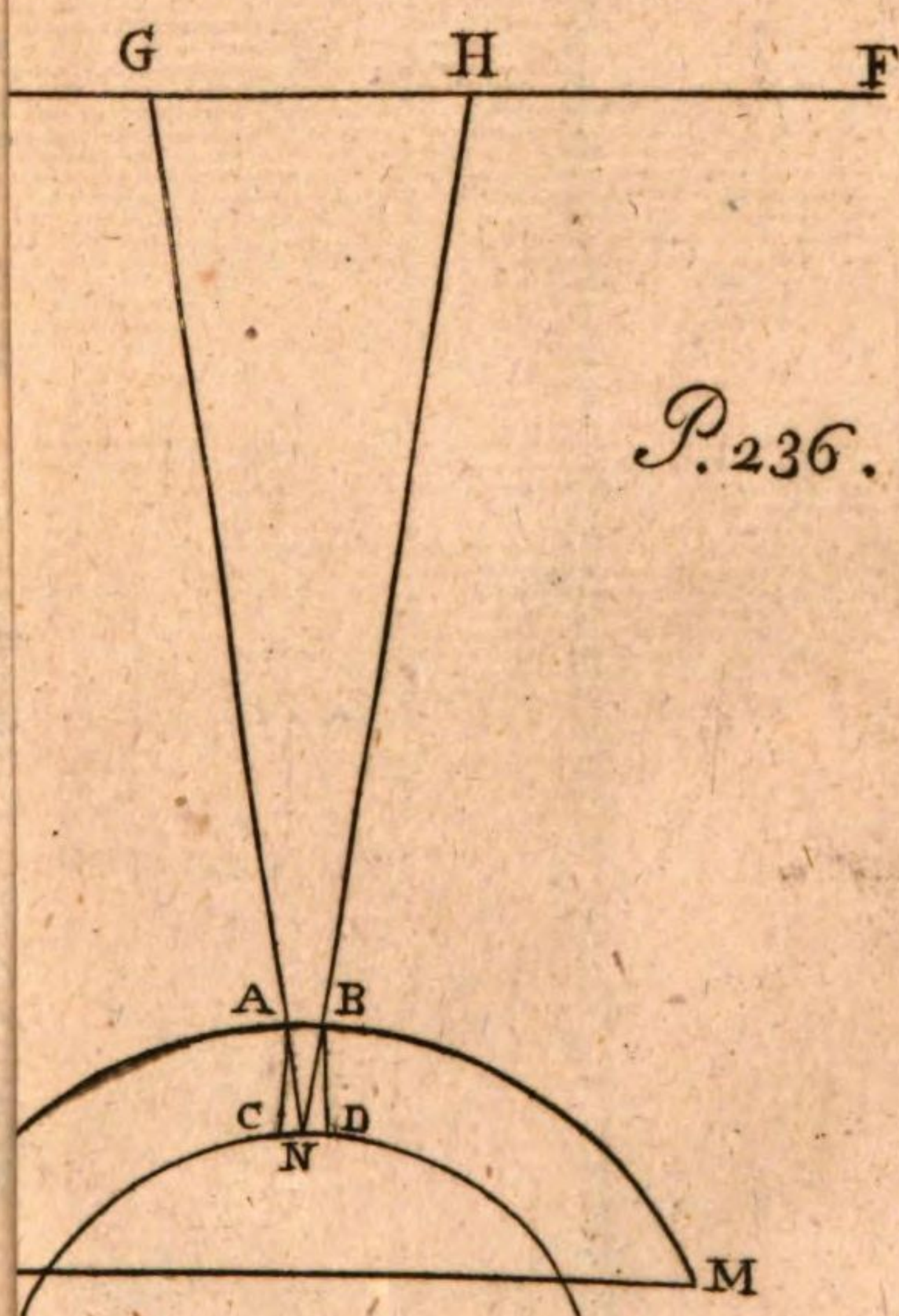


Plate VI.



P.236.



the Sine of the Arch D H and its Cosine : and because the Arches H E, H D, are equal, it is plain the force of the streams of the fluid particles whereby they will endeavour to turn the Circle round its Axis must also be equal ; but they being contrary one to another will hinder the action of each other in turning the Circle round. Just so whatever is the force of the particles of the fluid which falls upon any point in turning the Circle round from H by E and F there is another force which is equal to it, and endeavours to move the Circle the contrary way from H to D and L, which two forces will hinder each others effect in turning the Circle round ; the same thing is true of all the Circles that are parallel to the Ecliptick ; and therefore the motion of the fluid has no sort of effect upon the Sphere to turn it round an Axis perpendicular to the Axis of the Ecliptick. But notwithstanding its own motion and the motion of the fluid, it will remain indifferent to move round any of its Diameters as an Axis, the fluid having no effect in making it turn round one Diameter more than another.

I found fault with the *Theorist* for saying the Earth was inclin'd to the Ecliptick, it being impossible to conceive how a Sphere can be inclin'd to a Plane, passing thro' its Center as the Ecliptick does thro' the Center of the Earth. The *Defender* endeavours to excuse himself in this matter, telling us, it is

Q the

the expression of the ancient Philosophers, tho' he thinks it may be properly called an obliquation.

I would not have him raise a scandal on the ancient Philosophers without good grounds, which I scarce believe he has for his assertion; yet if they said any such thing, I did not think that the *Theorist* was so great an admirer of the old Philosophers, that in complaisance to them he would have spoken nonsense.

He tells me that *Situs rectus* is another expression I quarrel with; really tho' perhaps it is not very proper, I do not remember that I any where found fault with it; and he might have spared himself the trouble of citing a passage out of *Hugens* nothing to his purpose, for *Mons. Hugens* who always speaks sense, does not say that *Jupiter himself* but that his *Axis* is right to the Plane of his Orbit. But tho' the *Defender* endeavours to excuse the *Theorist* for his improprieties of expression, yet he passes over without any excuse the great error which he made in assigning the cause of the suppos'd change of position, which the Earths *Axis* suffer'd at the Deluge.

The *Theorist* said, that at first the Earth was equally pois'd, and therefore he thought it must keep its *Axis* steady and parallel to the *Axis* of the *Ecliptick*; but at the Deluge it lost the Equilibration as he calls it, and one end or Pole becoming heavier than the other, the heaviest end inclin'd towards the Sun,

Sun, in which said posture he says the Earth has ever since continu'd. I must acknowledge that I could not read this without some indignation, and am asham'd to find one who pretends to give a Mechanical account of the Creation, and of the changes the World has since underwent, discourse in so crude a manner, that it may clearly be seen that he has not so much as a common insight into that learning, which would have taught him the present posture of the Earth and its Axis. For I shew'd in the Examination, that every one that understood the Elements of the new Astronomy, knew perfectly that one Pole of the Earth was not more inclin'd to the Sun than another; and that if such a change had really happen'd to the Earth, *viz.* that one Pole of it had become heavier than the other, that Pole had always inclin'd to the Sun and made a perpetual Summer in all the places of the Hemisphere, while the other enjoy'd a continual Winter; and because no such thing happen'd, but both the Poles were equally inclin'd to the Sun, it was a demonstration that no such change of Gravitation happen'd to the Earth. The *Defender* is pleas'd to take no notice of this argument, and yet has the confidence to assert that, he thinks the *Theorist's* reasons very probable for the causes of the suppos'd change of the position of the Earths Axis.

Q 2

But

But the *Theorist* in the last Edition of his *English Theory*, seems to have found out another cause which he thinks in some measure contributed to the change of the Earth's position, and that it is the change of the Direction of the Magnetick particles, which he says followed upon the dissolution of the Earth. But before we can know if this would do, we must discover what these Magnetick particles are, what their direction is, what it was before the Deluge, what afterwards, how it came to be chang'd, and how this change produced a change in the position of the Earths Axis. And till he pretend to give a Mechanical account of these things, he can no more expect a distinct answer from me, than if he had said all this had been done by some occult quality. For loose and general Harangues about Effluvia, Particles, subtle Matter, Modes and Motions, signify very little more to explain Nature, than the Qualities and Attractions of the old Philosophers, (whom the *Theorist* upon this account so often derides) 'tis indeed but another sort of Cant, and affords as little satisfaction to the mind. Before I proceed any further, I must own I was mistaken when I said, that the Axis of *Jupiter* was oblique to the Plane of its Orbit. In reading of *Hugen's Systema Saturninum*, I remember'd that this position was affirm'd of *Saturn*, and I thought that I had read there that *Jupiter* had a like position, which I
wrote

wrote down without consulting the Book it self, which I had not then by me.

The *Defender* has mistaken my meaning, when he imagines I said, that according to to the *Theorist* both *Jupiter* and *Saturn* were Antediluvian Planets; for the particle *whom* in the parenthesis, refers only to *Jupiter*, tho' in the mean time I own the expression is ambiguous, and may refer to both.

At last the *Defender* comes to give us a short account of the *Theorist's* Creed as to this point, which he conceives to be thus, *The Earth was at first in an even and parallel posture with the Axis of the Sun, or (as he explains himself in the 2d. Page of his Reflections) its Axis was not oblique to the Axis of the Sun or the Ecliptick, but lay parallel with the Axis of the Sun, and perpendicular to the Plane of the Ecliptick. Then the Earth had a perpetual Equinox and unity of Seasons, and the Heavens and fixed Stars moved uniformly and concentrically with the Earth; but when the Earth changed its posture into that which it has now, it had the position of its Axis changed into a parallelism with the Axis of the Equator, and the Heavens seem'd to turn round upon another Axis different from those of the Sun or the Earth.* I must beg this Author's leave to say, that he has grossly misrepresented the *Theorist*, who, so far as I can discover never expressed himself to any such purpose. I thought that there were already errors enough in this Theory, so that he needed not have made them more

by false misrepresentations. For I can find no such thing in either the *Latin* or *English* Theory, as that the Axis of the Earth was ever parallel to the Axis of the Sun. It is said indeed that the Axis of the Earth was parallel to the Axis of the Ecliptick, and perpendicular to its Plane, and this I must own is false; but were it true, yet what the *Defender* advances upon it would be impossible, viz. that the Axis of the Earth would also be parallel to the Axis of the Sun, for since the Axis of the Sun is not perpendicular, but stands at oblique Angles upon the Plane of the Ecliptick, as is evident from *Gallileo* in his Book *de Macchie Solari*, *Scheiners Rosa Ursina*, *Kepler*, *Monf. Cassini*, *Mr. Flamsteed*, and most of the Astronomers who have wrote upon this subject: but even his own Master *Des Cartes*, (from whom he seems as industriously to dissent when he is in the right, as he is always sure to transcribe him when he is in the wrong) tells us, that the Axis of the Sun makes an Angle of seven degrees with the Axis of the Ecliptick: If I say what these Learned Men have observ'd be true, then either the proposition advanced by the *Defender*, or the 8th. of the 11th. of *Euclid* must be false. This Author also tells us, that before the Deluge (the Earth having a right position) the Heavens with the fixed Stars mov'd or seem'd to move concentrically with the Earth. I cannot suppose that he mean't by this, that all the fixed Stars
seem'd

seem'd to turn round the Earth in Circles, that have the Axis of the Earth for their Axis, for they do so now, and must do so whatever position the Earth obtains, if the motions of the Stars be only apparent and caused by the real rotation of the Earth round its Axis.

I fancy therefore that by a concentrical motion he means, (if he means any thing) that which is perform'd in a Circle which has the same Centre that the Earth has, (as the word implys) and I am confirm'd in the opinion, that this or some other strange thing is mean't by this word, because the *Theorist* in his *Archæolog.* asserts, that in his Primitive Earth all its Inhabitants would be *Ascii*, that is, they would have no shadow at twelve of the Clock, or they would have the Sun vertical to them at that time. This I dare venture to say is impossible in this or any other of the numberless Worlds, that the *Defender* dreams of among the fixed Stars, unless the Sun can be multiply'd or made to appear at many different places at the same time. For every one that ever read any one Page about the first principles of Geography knows, that all those who live under the same Meridian have twelve of the Clock at the same time, and consequently if the Sun were at twelve of the Clock vertical to all those who live under it, he must be in every point of that Meridian at the same time. I

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leave

leave the Reader to judge if these men whose notions in Astronomy and Geography are so distinct and clear, are not very capable of making Theories and discourses about the posture of the Primitive Earth, and the position of its Axis? They should be advis'd before ever they venture again to make another Theory, or defend this, to learn something of the common principles of the Sphere. Perhaps they think them too common and easy, and such as every body may know that will be at the pains to study, and therefore they despise them, and go upon higher attempts to find out something that no body else can discover; as the method how the Earth was made, and what was the state and condition of the Antediluvian World. But for my part I would rather be quite ignorant of the posture of the Primitive Earth and the position of its Axis, than not know the common principles of Astronomy and the doctrine of the Sphere. I am sure if this Author had spent but half the time upon this subject that he has done upon the Theory, he might have avoided many absurdities, and would not have talk't of the Axis of the Earth being chang'd into a parallelism with the Axis of the Equator, and the Heavens seeming to turn round upon an Axis different from that of the Earth. For it is well known, that the apparent motion of the Heavens is about the Axis of the Earth, and that the Axis of the Equator

tor is the same with the Earths Axis, and it is impossible that they could ever have been distinct.

It seems this *Defender's* acquaintance is only with the Antediluvian World; for one would think by his way of Writing, that he knew nothing at all of this Worlds position or motions. His discourse and terms are so odd and strange, that I sometimes believe they were terms that were used by the Antediluvian Fathers; for I am sure they cannot be accommodated to the present mode and manner of speaking.

The design of the fifth Chapter of the Examination is, to consider the *Theorist's* method of forming Rivers in the Primitive Earth; which, according to him were furnished with Vapours drawn from the Abyss thro' the Crust by the heat of the Sun. Against this I objected that from thence it would follow, that there could be no Rivers for a considerable time after the first Creation of the Earth. For one would think that it must necessarily require some time before the Suns heat could penetrate thro' a thick Crust to raise vapours from the Abyss; all which time the Inhabitants of the Earth must be without Rivers. The *Defender* thinks this objection may be answered by saying, that the Earth was at first soft and moist, and therefore could not but furnish store of vapours to supply the Rivers. But this is nothing but a shift; for
if

if we bring it to a Calculation, we shall find the cause no ways answerable to the effect.

I shew'd in the Examination, that the quantity of water evacuated by all the Rivers every Year, was at least equal to 263080 Cubical Miles; now if we allow no more Rivers in the Primitive Earth than there are now in ours, (whereas in our proportion to the surface of the Land they ought to be double) so many Cubical Miles of water will likewise be necessary every Year to supply the Primitive Rivers; and if we admit that the Sun had penetrated the thick Crust in the space of ten Years (which is a time little enough in all reason for such an effect) the quantity of water that would be necessary to supply the Rivers for such a time, must not be less than 263080 Cubical Miles; which is such a quantity as would make the Earth very soft and moist indeed: But it would be much rather a Marsh and Mire than an habitable Earth.

I objected also that it was impossible that the Rays of the Sun could ever reach thro' a vast thick Crust, so as to be able to raise vapours from the Abyfs. Or if we should suppose that it did raise them, yet it could not do it in such a quantity as would be requisite to furnish the Antediluvian Rivers. For who can imagine that the Sun could act as freely upon the Abyfs, as it does now upon the open Sea? Whose surface is expos'd to the continual heat
of

of the Sun, whereas the Abyfs was enclos'd by a thick Cruftation, in which were all the Materials of Earth, Sand, Clay, Gravel, Ores, and Metalline fubftances? And feeing the Sea as it is now laid open to the action of the Sun, is but juft fufficient to fupply us with Rain and Vapours; does it not feem a thing againft common fenfe to fuppofe that the Abyfs enclos'd with a thick fhell could have fent out a quantity of Vapours great enough for fuch an effect?

But I paffed from thefe general words, and reduced the matter to Calculation; where I fhew'd, that if we allow'd the mouths of all the Pores, Cracks and Chaps, thro' which the Sun muft have acted on the Abyfs to have been $\frac{1}{10000}$ part of the Earth's furface; there would then have been five thoufand times lefs Vapours to have ferv'd twice as great a quantity of dry Land; and therefore that in a Country as big as *Britain*, there would not have been fo much as one River, nor fo much Rain in a Year as does now fall in a day. All the answer the *Defender* makes to this, is, that I fuppofe great cracks and pitts thro' which the Vapours afcended, whose dimensions and capacities I examine at pleasure, whereas he does not find that the *Theorift* makes any mention of thefe Cracks for that purpofe; The only queftion is, whether the heat of the Sun could reach fo low as the Abyfs, when the Earth was dry'd and its Pores

Pores enlarged. Here he is mistaken, this is not the only question; for there is another material one besides, *viz.* That supposing the heat of the Sun had reached the Abyfs, whether there could have been vapours enough extracted from it to furnish the Earth. And I think I have prov'd that there could not.

But it seems he will not allow of the Calculation, because it supposes, that the Sun acted thro' large cracks, fissures and chaps, which he says the *Theorist* did not mention for any such purpose: but he will have the Sun to have acted only thro' the Pores of the Earth. Well, let us grant his supposition, that the Sun did not act thro' large cracks and fissures, (which I thought would best serve his design) but only thro' the Pores of the Earth; and we will see how much the *Theorist* will gain by it.

Let us therefore consider one of these Pores, which we will suppose to be one inch Diameter; (and I think it a good large one) let us also suppose that the Crust from its surface to the Abyfs is but one Mile thick, which is but a very moderate supposition, as in the figure, [*Fig. 13. Plate VI.*] where A B represents the mouth of one of these Pores, A C the thickness of the Crust, C N D the surface of the Abyfs, E G H F the Diameter of the Sun; G H is the Diameter of that part of the Sun which can shine all at once

once upon the point N, which is midway betwixt C and D, because AC is to CN as 5000 to half an inch, that is, as 120000 to 1 the Angle CAN will be somewhat less than two seconds; and therefore the double of it which is the Angle ANB or GNH will be less than four seconds; but the whole Diameter of the Sun subtends an Angle of 30 minutes, therefore EF the Diameter of the Sun, is to GH the Diameter of that part which shines thro' the Pore AB as 30 minutes are to four seconds, that is, as 1800 to 4 or 450 to 1. But Circles are to one another as the squares of their Diameters, and consequently the Disk of the Sun which shines all at once upon our Sea, is to that part of it which shines upon the Abyfs thro' its Pores, as the square of 450 to 1, that is, as 202500 to 1; and therefore the action of the Sun upon the surface of the Abyfs, would not be the two hundred thousandth part of what it is upon the surface of our new Ocean. But 'tis plain by the Figure, that the Sun could not shine the ten thousandth part of the time upon the Abyfs, that it can do upon the Sea. And therefore if we diminish its action also upon that account, we shall find that the heat of the Sun upon the Abyfs, would not be the ten millioneth part of what is upon the present Sea; and the vapours raised from the Abyfs, would be less than those which are raised from the Sea very near in the same proportion.

tion. Has not the *Theorist* now mended his cause mightily by this answer of his *Defenders*, which has made the argument against him much stronger than it was before?

I am accused of dealing unfairly with the *Theorist*, when I make him suppose that Mountains make way for the motion and dilatation of vapours. If this is unfair dealing, I cannot tell what will be fair; for the *Theorist* himself has expressly said so, in his Book II. Chap. 5. Parag. 4. of the *English Theory*. Where, speaking of the North and South parts of the World, which he says draw the vapours to them; his words are these, *The cold of those parts attracting them, as we call it, that is making way to their motion and dilatation without resistance, as Mountains and cold places usually draw vapours from the warmer.* Tho' I quoted these words in the Examination, yet the *Defender* assures us, that the *Theorist* supposes no such thing. It seems then that he can say one thing, and suppose another. If so, I wish the *Defender* would give us two Catalogues, one of those things which he says and supposes to be true, and another of those things he says without supposing them to be true; I hope in this last we should find what is said in the 7th. 8th. and 9th. Capters of the *Archæologiæ*, concerning the *Mosaical* account of the Formation of the World, its Primitive State, and the Fall of Man.

Our next dispute is about the course of the vapours. The *Theorist* asserted, that it would be towards North and South. Now I prov'd that it would be from East to West; because I demonstrated, that there must be a continual wind blowing that way, in an Earth where there were no Mountains to change the direction of the wind; just as it is now in the *Atlantick* and *Pacifick* Oceans. And seeing the vapours swim in an Air of the same intensive gravity with them themselves, it is demonstrable that they must follow the motion of that Air, and be likewise carry'd from East to West. The *Defender* grants, that their motion would be at first that way; But (says he) the question here is, where they would be condensed or where they would fall. I think it does not signify any thing where they fall; for I am sure they would not fall or be condensed in a place to which they were never carry'd, that is, towards either of the Poles.

The *Theorist* was of the opinion that the cold in the North and South parts attracted the vapours thither, that is, (as he explains it) made way for their motion and dilatation. But because I shew'd that this method favoured a little of absurdity, our Theory-mender says, that the vapours were diverted towards North and South, by an impulse of new vapours. This opinion seems to me to be as unnatural as the other, for if the vapours

pours were crowded on one another by their mutual impulses, they would condense one another, and fall down in the places where they were crowded.

I am sure it is impossible, that an atome of vapour however impell'd, should make its way thro' an Atmosphere of the same gravity with its self, for some thousands of Miles towards either of the Poles; when a stone which has some thousand times more density than vapours, and consequently some thousands of times also more force to break the resistance of the medium, if it were to move to Eternity in the Air, yet it would never make any considerable way in the medium, by reason of the continual loss of its motion.

It seems to contradict our senses to suppose, that vapours can move thro' the Air without suffering such a resistance as must condense them. We observe, that those vapours which are in the Clouds, when the Air grows light, begin to fall, no doubt in the form of vapours; but afterwards suffering a considerable resistance from the Air, they are condensed into drops of Rain. If then the resistance the vapours meet with for so small a way, be sufficient to condense them, is it not naturally impossible that they should travel some thousands of Miles and not be condensed till they arrive at the Poles?

Our Author proceeds in the next place to consider the seventh Chapter of the Examination,
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nation, and answer the arguments that are brought against the *Theorist's* way of making a Deluge. It is suppos'd in the Theory, that after some ages the heat of the Sun must have peirced thro' the Crust of the Earth, and reached the Abyfs, where it must have rari-
fy'd the waters there, and rais'd an immense quantity of them into vapours, these endeavouring to expand themselves, and the Pores of the Earth not being sufficient to let them pass thro', would press upon the Crust and break it into pieces, so that its fall upon the Abyfs, would produce an universal Deluge. Against this I objected, that it is impossible the heat of the Sun could reach far into the Earth, so as to perform any considerable effect; since by observation it was found, that in Caves and Vaults there was not any sensible alteration of heat in Summer and Winter; and therefore seeing that the heat of the Sun had so little effect in places of the Earth that were so near its surface, how could any one imagine that it would have any upon the Abyfs which was covered over with a thick Crust.

But because this argument was propos'd in general terms, I endeavour'd to bring it to Calculation, in order to which I assumed one postulatum, *viz.* That fewer Rays of heat passed to the Abyfs thro' the Crust, than if it had been compos'd of several surfaces at some considerable distance from one another (sup-
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pose 10, 20, or 30, feet) every one of which reflected half the Rays which fell upon them, and transmitted the other half. This I thought was a postulatum which every body would have granted; and if we consider how much of the Suns light and heat is diminished by a thin Cloud of vapours, placed between it and us, and how much light is reflected by the common Air, when it passes thro' it, we cannot but own that the diminution of heat in passing thro' every 20 or 30 foot of a solid Crust, must be at least the half of what falls upon it. Upon this supposition I shew'd, that if there were but one hundred of these surfaces, the number of Rays which fell upon the first, would be to the number of Rays which fell upon the last, as 2^{99} to 1 or as the 99th, power of 2 to unity; from whence it followed, that if we took the distances as the Logarithms, the heat of the Sun at each of these distances, would be as the absolute numbers belonging to these Logarithms; [Fig. 14. Plate VII.] Thus, if A B represented the thickness of the Crust, A C the number of Rays which fell upon the surface at A, D E the number of Rays which fell upon the surface at D; and if we draw thro' the points C and E the Logarithmick curve to the Asymptote A B, the Applicate B F will represent the number of Rays which will fall upon the surface at B, which in our present case is vastly less than A C.

Instead

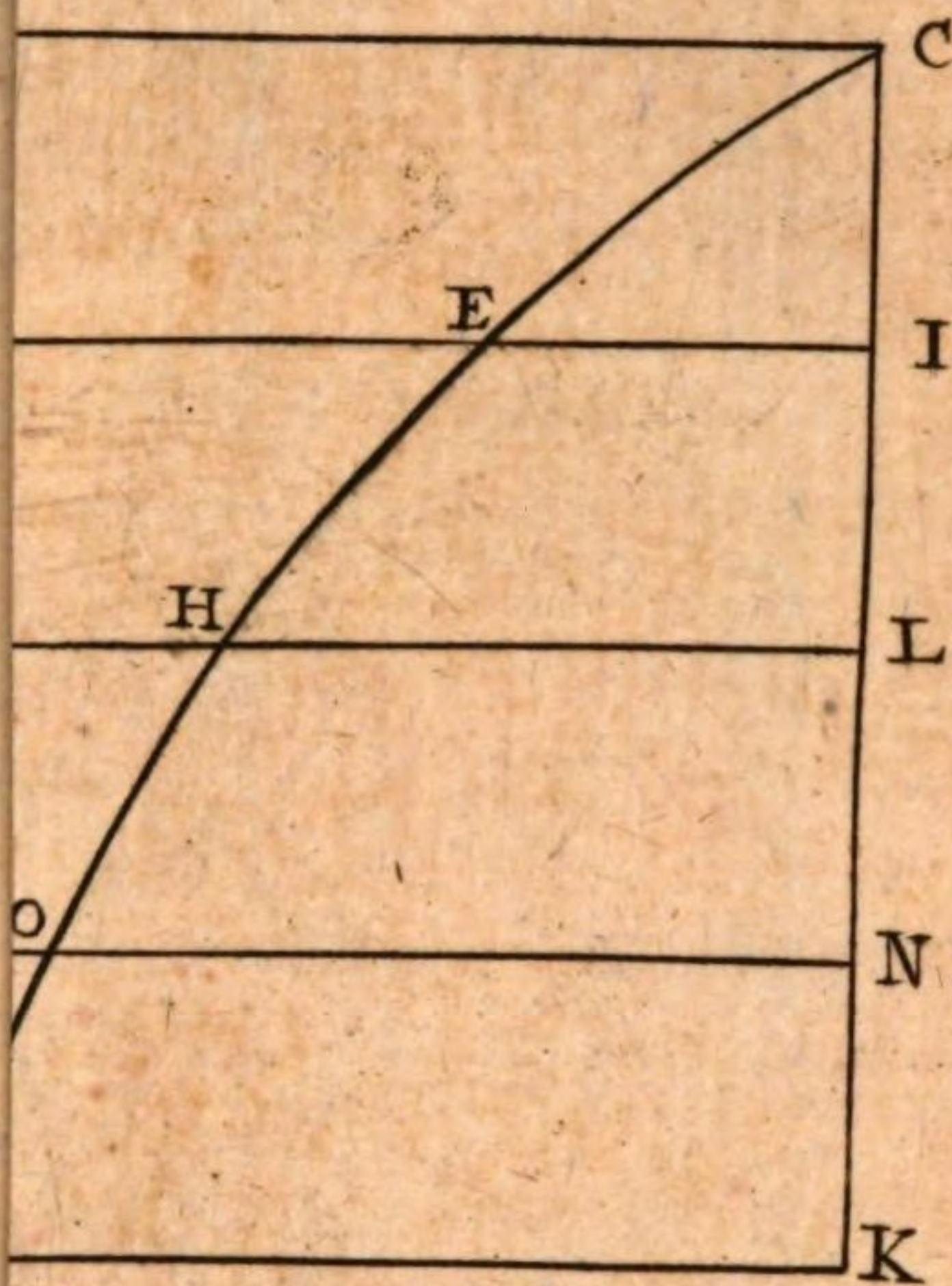
Instead of denying any of the propositions of this argument, or shewing how the conclusion is falsly deduced from the premises, he answers that so we may divide an inch into an hundred or a thousand surfaces, and prove from thence that no heat of the Sun could pierce thro' an inch of Earth. But is this a parallel case, is there not a vast disproportion between an inch of Earth, and a vast dense Crust of some Miles thickness? So that the postulatum which is true in the one case, cannot be suppos'd to be true in the other; if we should suppose as many surfaces in one inch of Earth as we did in the whole Crust, then the distance between any two immediate surfaces of the Crust, would be to the distance between two immediate surfaces of the inch of Earth, as the thickness of the Crust to the thickness of an inch; and consequently if A D represent the distance between the two first surfaces of the inch of Earth, A B the distance between the two first surfaces of the Crust, A C the Rays which fall on the first surface of both, E D the number of Rays which fall on the surface at D; the line F B which is the Applicate of the Logarithmick curve D E F, will represent the number of Rays which fall on the surface at B. For it is certain that the deeper any Rays pass in any medium whether solid or fluid, they are still the fewer, and both light and heat are more and more diminished. Thus the Rays

of the Sun passing thro' a far greater portion of the Air when it is near the *Horizon*, than when it is near the *Zenith*, is the cause that its light near the *Horizon* is much less than when he is in his Meridian Altitude; and the difference of his Illumination in both these places is so great, that we can easily look upon the Sun when he is Setting or Rising, whereas we cannot turn our eyes to him without hurting them, when he is near our *Zenith*. Thus also it is observ'd by experience, that the deeper any Pool of water is, the fewer are the Rays which reach to the bottom of it; the same thing is also observ'd, if the medium is Glass or Chrystal, or any other that lets either light or heat pass thro' it.

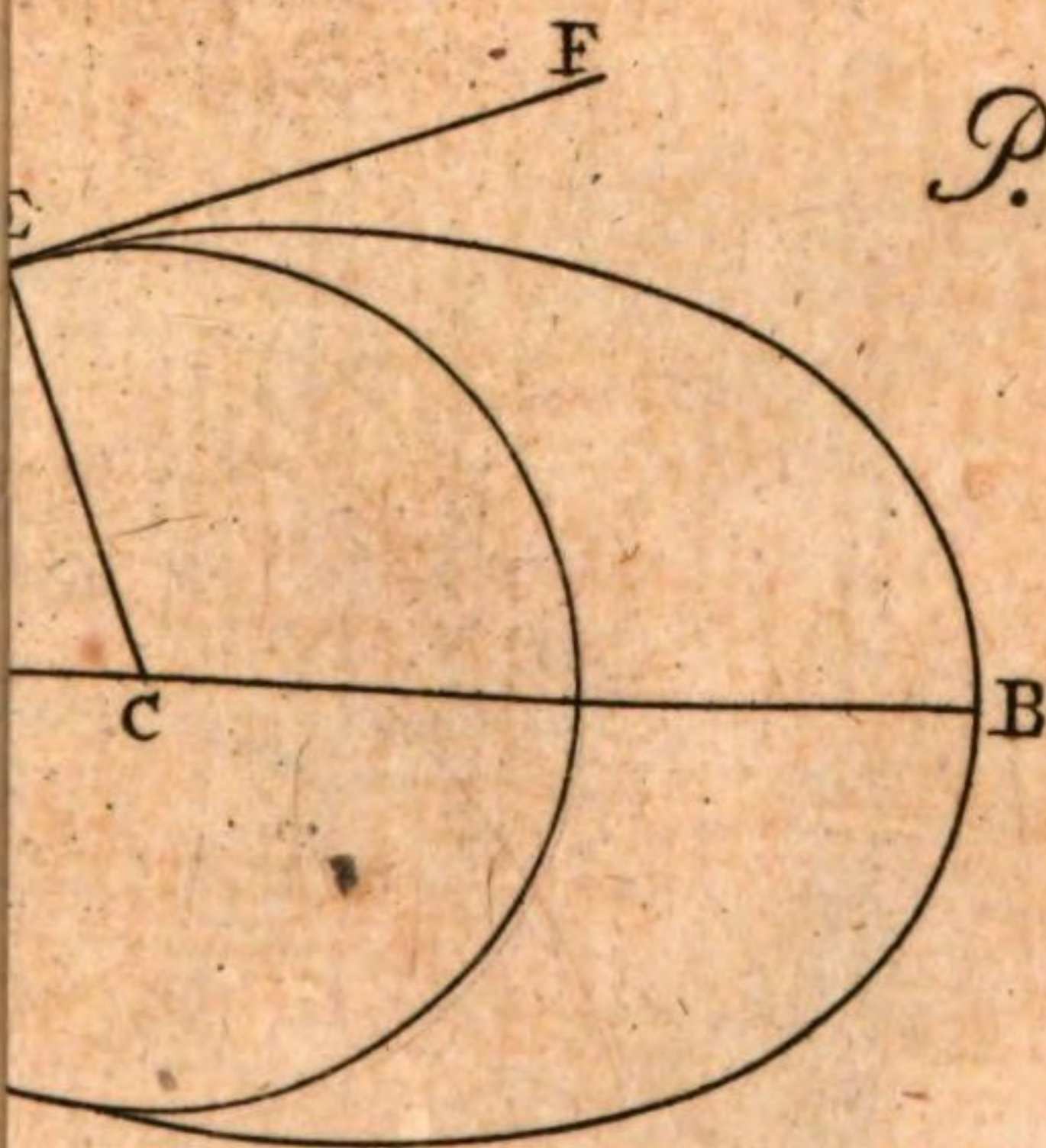
Perhaps the *Defender* will say, that the Rays are diminished in passing thro' a medium; but yet he does not see how they should be diminished in the proportion I have assign'd, *viz.* so that the Applicates to the Logarithmick curve are always as the quantity of Rays which pass thro'. Well, that he may see that this is not a precarious assumption, I will give him my reason for it.

Let A B K C represent any medium thro' which the Rays pass; let us suppose this medium to be divided into parts of equal thickness, A D, D G, G M, &c. let a represent the number of Rays which fall on the surface A C, and let $\frac{1}{m}a$ be those which pass thro'

Plate VII



*P*_{242.}
244.



P. 274.

to the surface DI ; because the mediums AI , DL , are uniform, they will both transmit the light which falls upon them, in the same proportion, that is, because both these mediums are by supposition of the same nature, equally dense, and of the same thickness, and the Rays which fall upon both, have the same inclination, the quantity of Rays which fall upon the surface AC , will be to the quantity which passes thro' the medium AI and comes to the surface DI as that quantity which comes to DI is to the quantity which passes thro' DL , and comes to LC and by consequence if a represent the number of Rays which fall upon AC , $\frac{1}{m}a$ the number which fall upon DI , $\frac{mm}{1}a$ will represent the number of those that fall upon the surface GL . After the same manner $\frac{m^3}{1}a$ will be as the number of those Rays which come to MN , and $\frac{m^4}{1}a$ will be the number of those which fall upon FB , that is, If the distances AD , AG , AM , AB , are in an Arithmetical progression, the Applicates AC , DE , GH , MO , FB , which represent the number of Rays that come to the points A , D , G , M , B , respectively, will be in a Geometrical progression, which is the property of the Logarithmick curve.

Tho' this way of reasoning by a Calculus, seems to be plain and obvious enough to those who understand the common principles of Calculation, (which as I think ought to be unknown to none that pretend either to write or defend a Theory, as the *Theorist* himself owns) yet the *Defender* does whatever he can to find shifts and evasions for such arguments; and here he tells us, that we ought not to consider surfaces but pores. Well, that he may see how ready I am to please and obey him, I have done this already in the 237th Page of this Treatise, where I have shew'd, that if the Sun shin'd upon any surface that is exposed openly to it, its heat on that surface would be 202500 times greater than its heat upon the surface of the Abyss, when it shin'd only thro' the Pores of the Crust. Which disproportion is great enough to shew, that no great store of vapours could be rarify'd in the Abyss. But says he, those that allow a Comet at its nearest approach to the Sun, to be pierced thro' and thro', so as to become hotter than red hot iron, will not think it strange that at our distance, it should have some proportional effect upon the inward parts of the Earth. Let us illustrate his similitude by another; Those who allow that a ball of iron ten inches thick, when put in a good fire may be made red hot, and be peirced by the fire thro' and thro', will not think it strange, that this ball of iron remov'd
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10 feet from the fire, should receive some proportionable heat even in its inward parts, as without doubt it would. But the question is, if this effect is any way sensible, or if we should suppose some water inclosed in the middle of this ball, whether the heat of the fire could raise it into vapour at such a distance, so that the force those vapours have to expand themselves, would break or burst the ball.

I thought that this Gentleman had known so much of the new Experimental Philosophy, as not to be ignorant, that heat does not pass into the interior parts of a solid of considerable thickness, till it has quite dissolved the Exterior parts; and if the solid is combustible, (as wood) it consumes the outward parts, before it has any sensible effect upon the Interior; but if its parts are compact, (as Metals or Stone) it loosens and dissolves the frame and texture of the outward parts, and so makes its way to the inward.

But our Philosopher thinks he has found out one remarkable *Phænomenon*, by which he can prove effectually, that the heat of the Sun peirces deep into the Crust, and that is in the case of the Earthquakes. He considers the cause of them, and their depths, and he says, that all agree that they arise from the rarefaction of Vapours and Exhalations; This rarefaction (says he) must be made by some heat, and no other is prov'd

to us yet by this Author, than the heat of the Sun.

Why should I be oblig'd to satisfy him in all his difficulties in Philosophy? Did ever I set up to be a *Theorist*, and give an account of all the *Phænomena* of Nature? Well; but it seems he expects it from me, and tho' I am no ways oblig'd to it, yet out of abundance of good nature, I will give my opinion in this matter.

I think then that the rarefaction of Vapours within the Earth, may arise from another heat than that of the Sun. We know that there is an actual fire which always burns in several places of it, which sometimes bursts out and makes an horrible eruption, as in all Vulcano's and Fiery Mountains; and why may not this fire be the cause of the rarefaction? This appears to be more probable, because Earthquakes are most common in those places where these Vulcanos are, as in the Kingdom of *Naples* and *Sicily*.

But supposing there were no actual fire under ground, yet I am of the opinion, that heat may arise from other causes than that of the Sun. It is observ'd, that from a due mixture of some particles of matter with those of another sort, there will arise a very considerable heat: Some places underground are observ'd to be exceeding hot, as some Mines, (where there is a mixture of Sulphureous, Nitrous, and Mineral principles) the heat is
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so considerable, that a Man cannot easily endure it, even in the extremity of Winter. There are other places so warm, that the waters that run thro' them will scald a Mans hand. And may we not suppose, that there are some Cavities deeper underground, where the Earth is of the same frame and texture of parts? Now if some Sulphureous and Nitrous Exhalations, should be gathered together within any of these Cavities, and by motion, or any other accident, they should happen to be kindled, it is plain they will expand themselves, rarify the Air, and make that Concussion of the ground we usually observe in Earthquakes.

Now it is plain, that these Exhalations may be kindled without the heat of the Sun, from observations that are daily to be made in our Atmosphere; where the Sulphureous Exhalations that are the cause of Thunder and Lightning are kindled in the Air, when the action of the Sun is not strong. This is also observ'd of Meteors, (which we commonly call falling Stars) whose matter is kindled in the night-time, when the immediate heat of the Sun can have as little effect as it has within the bowels of the Earth: and I hope this will be sufficient to satisfy him, that Earthquakes may arise from other causes than the heat of the Sun.

Tho' the arguments I have already given, clearly prove, that there was no rarefaction
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of the vapours, caused by the heat of the Sun within the Abyfs, yet I shew'd, that granting the Suns heat had reach't the Abyfs, even then an Universal Deluge could not follow from thence; because I demonstrated by a Calculation, that if the Suns heat drew vapours from the Abyfs sufficient to furnish the Rivers on the Earth, it must have exhausted this great treasure long before the time of the Deluge. This manner of Examining the *Defender* calls contention, and going from one extream to another; tho' for my part, I think there cannot be fairer dealing, than first to prove that his Principles and Hypotheses are false and disagreeable to Nature; and then (supposing them true) to shew, that his reasonings upon 'em are false and inconclusive, and the causes he assigns are no ways proportionable to the effects he would account for.

However, our Author assures us, that there are a great many uncertainties in the computation. He knows I did not pretend to give an exact estimation of the Water that the Rivers sent into the Sea. I can suppose that I have not come within the truth by one, two, or three Cubical Miles of Water, (which is as much as I need to allow) nay, I will grant him, that I have erred a twentieth part, or even one half if he pleases, and yet the argument will be strong enough. For according to the computation, the Abyfs ought
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to have been exhausted in the space of 460 Years; now from the Creation to the time of the Deluge, there were 1600 Years. By which it is evident, that which ever of these Hypotheses he takes, the Abyfs must have been empty long before the time of the Deluge.

But he thinks I go in this Calculation on principles that are not allow'd by the *Theorist*, because I suppose the Waters of the present Sea equal to the Waters of the great Abyfs; whereas (says he) there was near twice as much Water in the great deep, as is now in the Ocean, seeing the Abyfs was extended under the whole Earth, and the Sea reaches but to the half of it. I always presum'd that it was the *Theorist's* Hypothesis, that the Crust fell down upon the Abyfs and drove the Waters from their place, so that the greatest part of the Waters in the Abyfs (after they had overflowed the Earth) came and settled at last in the Sea. There might indeed have been some Water left in the Hollows and Cavities of the Earth, but 'twould be inconsiderable in respect of the whole; and the *Theorist* himself asserts, that if the Earth should disgorge all the Waters in its bowels, it would not amount to above half an Ocean; and in the *Latin* Edition he thinks, that it is altogether incredible, that the Water within the Earth should be as great as what is in the Sea and Rivers. So that this Gentleman,
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who asserts that there was almost twice as much Water in the Abyfs as there is now in the Ocean, seems never to have read the Theory, or to have understood the *Theorist's* Hypothesis which he endeavours to defend.

But what if there were twice as much Water in the Abyfs as there is now in the Ocean; yet even in that case the whole must have been exhausted long before the Deluge, since one Ocean could have been drawn up in the space of 460 Years: Nay, if we suppose that there were but just so many Rivers in the Primitive Earth as there are now in ours; (whereas in proportion to the dry Land there ought to have been twice as many) yet in the space of 1600 Years, there is time enough to have the whole Abyfs exhausted, as is evident by the Calculation.

The *Defender* alledges, that the Rivers were not supply'd by the vapours, only from the Abyfs, but also from the Earth and Waters upon it. This evasion was foreseen, and obviated by me in the 130th Page of the Examination; where I prov'd that there must be at least the same quantity of vapour exhal'd from the Abyfs as was before, because the same cause still continuing to act, would still produce the same effect, and the Abyfs having at first furnished the Rivers with a sufficient quantity of Water, would still continue to furnish 'em in the same quantity, nay rather in a much greater; since (according to the

the Theory) the heat of the Sun was stronger and stronger every day upon the Abyfs, and the vapours exhal'd were ſo many at laſt, that not being all of them able to crowd thro' the Pores, they broke the thick Cruſt of the Earth with their violent effect to expand themſelves and fly upwards. Thus we ſee all the ſhifts and evaſions which this Author makes, are not of the leaſt weight againſt my computation.

But ſuppoſing that all the Water in the preſent Ocean was then in the Abyfs, yet I prov'd, that from the fall of the Cruſt, there could ariſe no Univerſal Deluge, becauſe the *Theoriſt* himſelf prov'd, that there muſt be at leaſt eight Oceans of Water requir'd to cover the Earth. The *Defender* confeſſes, that the Water in the Abyfs was not ſufficient to make a Deluge in the nature of a ſtanding Pool, over-topping and ſtanding calm over the heads of the higheſt Mountains; (as it is uſually conceiv'd) but the Deluge that roſe from the fall of the Cruſt was rather like a ruſhing Sea, overflowing and ſweeping them with its Raging Waves and Impetuous Fluctuations. I beg the *Theoriſt's* pardon for miſtaking him: I thought that he deſign'd to explain *Noah's* Deluge, and not one of his own imagination. Now I can eaſily prove, that ſuch a Deluge as this Gentleman conceives, is no ways like that which happen'd in the days of *Noah*. For tho' the *Theoriſt*
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computed but eight Oceans of Water that were sufficient to cover the whole Earth above the tops of the highest Mountains, yet I determined the quantity more nicely in my Remarks on Mr. *Whiston's Theory*, where I prov'd, that there must be at least three and twenty Oceans of Water that were necessary for such an effect. From which it is evident, that the Water in the Abyfs could but cover one part of twenty three at a time, and the other twenty two parts must remain dry; and that after the Water had overflowed this part, it must have proceeded to the next, and so successively, till at last it had overflow'd the whole Earth. This is the way that our Author must conceive the Deluge.

Let us see now what account the Scriptures give us of *Noah's Deluge*. *Genes. Chap. 7. v. 2.* it is said, *That the fountains of the great deep were broken up, and the windows of heaven were opened, and the rain was upon the Earth forty days and forty nights.* And again, *vers. 17. And the flood was forty days upon the Earth, and the waters encreased and bare up the Ark, and it was lift up above the Earth.* *vers. 18. And the waters prevailed, and were encreased greatly upon the Earth, and the Ark went upon the face of the waters.* *vers. 19. And the waters prevailed exceedingly upon the Earth, and all the high hills that were under the whole heavens were covered.* *vers. 20. Fifteen cubits upwards did the waters prevail, and the mountains were covered.*

covered. vers. 24. And the waters prevailed upon the Earth an hundred and fifty days. Chap. 8. vers. 1. And God made a wind to pass over the Earth, and the waters asswaged. vers. 2. The fountains also of the deep and the windows of heaven were stopped, and the rain from heaven was restrained. vers. 3. And the waters returned from off the Earth continually, and after the end of the hundred and fifty days, the waters were abated. vers. 5. And the waters decreased continually until the tenth month. In the tenth month, on the fifth day of the month were the tops of the mountains seen.

We may observe from this, that the Scriptures inform us, that the whole Earth was under a Deluge at the same time, that the waters encreased and prevailed gradually every where for the space of 150 days, that all the high hills under the whole heavens were covered, that all these Mountains lay under Water for several months, that the Ark swam and was carry'd up above the Mountains, and when the Waters began to abate, it rested at last upon one of them; that it was the eighth month from the beginning of the Deluge when the tops of the Mountains first began to appear, till which time they lay all of them hid and covered with Water. Now in the *Theorist's* imaginary Deluge, it is plain, (as I have already observ'd) that there was but a twenty third part of the Earth covered with Water at the same time;
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it is also evident, that the Waters could not encrease gradually in any one place for the space of 150 days, since the whole Earth was to be cover'd over with waters in that time. His single Ocean of Water could not stay but the three and twentieth part of that time in one place, and therefore it must have gone off from that place, and left it dry long before the end of those days.

Nor is this Idea of a Deluge less consistent with Reason and Philosophy, than it is with Scripture. Is it possible to conceive moving, wandring Mountain of Water? For Water naturally settles its self into a surface concentrical to the Earth; and by whatever force, or however it should be rais'd into an heap, it will immediately spread it self uniformly upon the surface of the Earth, and descend by whatever ways it can. If therefore we should suppose all the waters in the Abyss drawn or forced up to cover the hills of any one place, it will immediately descend and form it self into a surface parallel to the *Horizon*, and so spread its self equally every where upon the Valleys of the Earth, leaving the Mountains quite uncover'd. The *Theorist* himself acknowledges, that a Mountain of Water is an impossible thing; and indeed, this notion of a Deluge seems to be so extravagant, that I can scarce think that any body will be so credulous as to believe it; and yet it is impossible that it can be any other ways, if we suppose

suppose all the Mountains of the Earth to have been cover'd with an Ocean of Water, of no greater dimensions than that assign'd in the Theory, which cannot cover more than the three and twentieth part of the Earths surface.

The *Defender* in vain alledges, that we are to conceive this Ocean as a mighty rushing Sea, overflowing and sweeping with its raging Waves and Impetuous Fluctuations, all the Mountains; for this will not at all take away the absurdity, because motion can never multiply any body, nor make it to be at more places than one at a time. Water can only by motion be in many places successively, which will give us the Idea of such a moving heap or Mountain of waters, as we have just now prov'd impossible. Nor is this notion of a Deluge agreeable to the principles of the Theory. For let us suppose the Crust to have been broken by the force of vapours endeavouring to expand themselves, it must immediately fall down and drive the Water of the Abyſs out of its place, some one way, and some another; this Water will ascend with a very considerable force, let us suppose as far as five Miles perpendicular height, after which it will descend again and fall to the ground; and all this will be by computation in much less time than one day. These waters having acquired a great force by their fall, will descend very swiftly into the Vallies
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and Cavities of the Earth, and leave both Mountains and Upper-grounds quite uncovered. And as the Waters that were raised by the fall of the Crust, could cover no more than a twenty third part of the Earths surface, so it is evident it could remain but a very short time upon the tops of those Mountains it overflow'd; whereas in *Noah's* Deluge, all the Mountains of the Earth lay under water for the space of 150 days. Thus I have prov'd, that the Deluge the *Defender* endeavour'd to explain, is neither consistent with the holy Scriptures, true Reason and Philosophy, nor the Principles of the Theory, from whence he pretends to deduce it.

Of the Figure of the Earth.

TH O' what the *Theorist* has said in relation to the Figure of the Earth, be one of his grossest and most palpable errors, and tho' there is a positive demonstration that it is of a Figure directly contrary to that he assigns, yet his *Defender* thinks himself oblig'd to maintain it, and therefore spends more time and paper about it, than upon any other point.

He is not contented with what has been said by several Mathematicians and Philosophers of the present Age upon this Subject; tho' one would think that they knew the methods

thods to determine the Figure of the Earth much better than either the *Theorist* or himself. He is afraid that they will give it against him, and therefore he appeals from them to some farther Observations, that He and the *Theorist* point out and direct us to make. As to observe for instance, whether the extent of a degree be the same in different Latitudes, or whether the shadow of the Earth in a total Eclipse of the Moon be truly round; as also to observe if towards the Poles, the return of the Sun to their Horizon be according to the rules of a Sphærical Surface of the Earth. These are the Observations the *Theorist* would have made to determine the controversy. Which I will now consider, leaving the *Defenders* Observations to be examined in a proper place.

I noted in the Examination, that I did not think any Observations that could be made upon different measures of a Degree in different Latitudes, could be so nice and exact, as would be necessary to determine the point in controversy. For supposing that the greatest Diameter of the Earth were to its least as 101 to 100, by which one Semi-diameter would be very near 40 Miles greater than the other; (a difference which his friend who was so kind as to write him a Letter, thinks to be much too great) and then the greatest Degree upon the Meridian, would be to the least very near in the same

proportion; that is, it would be 1 part of 100 greater than the other; but this difference is so very small, that I believe no Observations in order to this discovery, are nice enough to be rely'd upon. For where the length of a Degree in Miles is determin'd either by the resolution of many right-lined or Spherical Triangles, it is scarcely probable, that the errors in Observations and Measuring, will amount to less than $\frac{2}{3}$ of a Mile.

Tho' therefore we can scarce hope of ever attaining to a knowledge of the Earths Figure by measuring of it, yet to satisfy the *Theorist* in this matter, I took notice of one Dr. *Eisenschmidt*, who compares the magnitude of Degrees observ'd in different Latitudes, and finds that they are greater at the Equator than at the Poles, and that they gradually decreased from the Equator towards either of the Poles; from which he infers, that the Earth is of such a Figure as the *Theorist* has assign'd to it, whereas I following the *Theorists* principles, demonstrated that the Earth must have another Figure, and that the Diameter of the Equator must be greater than its Axis.

But our *Defender* says, that my demonstration proceeds upon a supposition, that the *Vertical Lines* or the *Lines of Gravity* (I suppose he means the Lines of direction of heavy Bodies) are to be drawn directly to the Center. Does not the *Theorist* admit of the

the same supposition? Does not he make the Water descend from the Poles to the Equator, that it may be so much nigher to the Center? Since therefore according to the *Theorist*, the Lines of direction of heavy Bodies are towards the Center of the Earth, and (if we proceed upon that Hypothesis) where the Degrees are greatest, there the Earth must have its Diameter greatest, it will evidently follow from *Eisenschmidt's* Observations, that the Earth must not be an oblong Spheroid but a broad one, and have its Axis shorter than the Diameter of its Equator.

Our *Defender* tells us, that Dr. *Eisenschmidt* supposes the Vertical Lines or Lines of Gravity, to be drawn at right Angles to the Tangent of each respective Horizon. What Dr. *Eisenschmidt* does really suppose I know not, but I am sure he cannot suppose a thing more absurd than what our Author makes him suppose in this place. For that the Line of direction of heavy Bodies is at right Angles with the Tangent of the Horizon, is to me such an incomprehensible supposition, that I shall excuse my self from considering of it, till the *Defender* (who I suppose would have us think he understands it) is at leisure to explain it.

I have not seen Dr. *Eisenschmidt's* own Book, to know upon what principles he proceeds: It is said in the *Acta Eruditorum*, that he embraced the *Theorist's* opinion about the Figure of the Earth; and I believ'd that therefore

he would follow his and the common opinion, that all heavy Bodies tend toward the Center of the Earth; because it seems most reasonable, that the direction of heavy Bodies should be towards the Earth's Center of Gravity, which we may suppose to be the same with its Center of Magnitude. Nor can we suppose this direction to be any ways chang'd, but upon the account of the centrifugal force, that all Bodies in the Earth have acquir'd by being turn'd round the Earth's Axis. Now if he had taken the Centrifugal force into his consideration, he must have concluded (as I have done) that the Earth had the Diameter of its Equator greater than its Axis, which is still contrary to the conclusion he made. So we see, that whether this Author supposes the direction of heavy Bodies to be towards the Center of the Earth, that then by Observations he must have concluded, the Earth to have been of a broad Spheroidical Figure; or whether he supposes the Lines of direction of heavy Bodies to be chang'd by a Centrifugal force, he ought to have drawn the same consequence from thence, tho' not indeed from his Observations of a degree measured in several Latitudes.

The *Defender* not daring to trust much to his own skill in this matter, has obtain'd a Letter from a Gentleman of his acquaintance concerning it. But all that Gentleman's reasons depend on a supposition which the *Theorist* cannot allow, viz. That the Tangents of
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of the Ellipse are in the Horizontal Plane; whereas it is evident, that according to the *Theorist's* Hypothesis, these Tangents can never represent the Horizons, for he makes the Water to run from them down to the Equator: now it is certain that Water will not run if it be placed upon an Horizontal Plane; and if we are to make Water run any way, we must always make its Channel inclined to the Horizon.

This Gentleman indeed reasons truly, provided the Lines of direction of heavy Bodies were always perpendicular to a Plane, touching the Spheroid in the point where the Body falls; but as I have already observ'd, this supposition is not to be admitted by the *Theorist*, and we can no more suppose a Plane touching a Spheroid to be the Horizon of the point where it touches, than we can suppose a Man who stands upon the side of a Hill, to have that plane for his Horizon which touches the side of the Hill in the point of his station.

Thus, I think I have plainly prov'd, that there is no certain way to determine the Figure of the Earth from the observations of a degree taken in several Latitudes; yet I have shewn, that if either the *Theorist* or his *Defender* will depend upon those observations which are already made; we must conclude from their own principles by evident demonstration, that the Earth is of a very different Figure from what they assign it.

The next way the *Theorist* would take to determine the Earth's Figure, is by its shadow upon the Moon: But it is easy to prove this way as uncertain as the other. For let us suppose (as we have done already) that the greatest Diameter of the Earth is to its least, as 101 to 100, (which is a much greater proportion than what is allowed either by Mr. *Newton* or Mons. *Hugens*) because by observation, the Diameter of the Earth's shadow, is three times the Diameter of the Moon, and the Moon appears under an Angle of 30 Minutes, therefore the Diameter of the Earth's shadow seen at that distance, will appear under an Angle of 90 minutes or a degree and half; and therefore if we suppose the Diameter of the shadow to be divided into an 100 equal parts, (the whole appearing under an Angle of 90 minutes) every one of these parts will be seen under an Angle of $\frac{90}{100}$ or $\frac{9}{10}$ parts of a minute; that is, in our present case, one Diameter of the shadow will appear under a greater Angle than the other, by $\frac{9}{10}$ parts of a minute. Now by experience we find, that any object that appears under an Angle that is less than a minute, is seen as if it were a point. It is therefore plain, that if there were a Lucid Body whose Disk is large enough to receive the whole shadow of the Earth, that we could observe no sensible difference between the length of its Diameters; but if this Lucid Body had its Disk but just big enough to receive a $\frac{1}{3}$ part of the Earth's shadow

shadow, (as it really is in the Moon) it is most evident that we could not determine the Figure of the shadow near so nicely, as in the former case. We see then that by the Earth's shadow upon the Moon, its Figure is not to be determined with any tolerable exactness.

The third observation the *Theorist* would have us make, is about the return of the Sun to the Polar parts of the Earth, whether that be according to the rules of a Spherical surface. But this method is as little to be rely'd upon as any of the rest. The various refractions of the cold and thick Atmosphere, make all observations that are made there, very doubtful and uncertain: Besides, the Latitudes of those places that are near the Poles, are not exactly determin'd, so that there is no trusting to observations that have been already made, and I believe no body will go now to these places and Winter in them, on purpose to make new and more exact observations to determine this controversy.

The *Defender*, having thus pointed out the *Theorist's* own observations, comes now to consider the arguments that are brought by those, who say that the Earth is of a broad Spheroidical Figure. He tells us, that the learned Mr. *Hugens* thinks it may be prov'd by experiments made about the different Vibrations of a Pendulum in different Latitudes; and brings an instance of an experiment made at *Cayenne* in *America*, where it was observ'd, that a Pendulum Vibrating in a second is shorter

shorter than one at *Paris* that performs its Vibrations in that time; from which he says, he concludes that Gravitation is less under and near the Equator than towards the Poles, and from thence, that the Figure of the Earth is protuberant and rises in the middle, its shortest Diameter being betwixt Pole and Pole.

We see here that our Author ascribes the observation about the Figure of the Earth, drawn from an experiment of Pendulums to *Monf. Hugen*s, whereas it was *Mr. Newton* who first made the discovery, from whom *Mr. Hugen*s had it; and this Writer in justice ought to have ascribed it to its true and genuine Author. But this is not the first time that the honour of several noble Inventions, which the World owes to that excellent Geometer and Philosopher, has been given to others.

The *Defender* tells us, that there are several things to be considered before we come to the conclusion; first the matter of fact, concerning the inequality of Vibrations of equal Pendulums in different Latitudes; and then the inferences made from that inequality. As to the matter of fact, he tells us, that it was *Mr. Richer* who made the experiment, whose Person or Character he does not know, or whether his relation be extant in Print. 'Tis strange, that the *Defender* thinks that no body is to be trusted in a Philosophical experiment; but those whose Persons and Characters he knows.

knows. Has he such an universal acquaintance, as to have an exact knowledge of all those who are fit to make Observations and Experiments in Natural Philosophy? Certainly he must think, that the Gentlemen of the Royal Academy are better Judges of that than he is. *Monf. Richer* was chosen by them, and sent at the command and charges of the *French* King, to make Observations in the South parts of the World; and doubtless, when these Observations were to be made by order, and at the expences of their King and Patron, they would never choose any but one whom they knew to be well qualify'd for such an undertaking. And *Monf. Richer* himself has justify'd the judgement of those that chose him, by his excellent Observations, both Astronomical and Physical, that have been so well received by the Learned. Among the rest, he gives us an account of this Observation about the Pendulum very exactly; He tells us, that during the ten months he stay'd at *Cayenne*, there scarce passed a week in which he did not make the Observation, and found it always the same.

Monf. Vaun, *Monf. Hayes*, and *Monf. Du Gloss*, were also chosen by the same Academy, and sent to the Island *Goree* in *Africk*. They had it particularly in their instructions, to make Observations about the Pendulums; which they did, and confirm'd the Experiments made by *Monf. Richer*. We may see a particular account of all their Observations
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in the *Recueil des Observations faites en divers Voyages per l'ordre de sa Majesté*, in Fol. printed at the Royal Prefs in *Paris*.

To all this we may add, that the ingenious Mr. *Halley* when he went to *St. Helena*, (having first fitted the length of his Pendulums for Vibrating seconds at *London*) found afterwards that length at *St. Helena* to be too great; and therefore he was forced to shorten it, that it might Vibrate seconds there; tho' he did not then observe the exact difference between them. These repeated Experiments I hope will put the matter of fact past all doubt.

But (says our Author) even Mons. *Hugens* speaks dubiously of the Experiment. This I deny; for Mons. *Hugens* never in the least doubted of the Experiment, viz. That a Pendulum Vibrating seconds at the Equator, must be shorter than a Pendulum performing its Vibrations in the same time at *Paris*; for he has given evident demonstration that it must be so. Mons. *Hugens* only doubted whether Mons. *Richer* had observed exactly the difference of their lengths; being fully assured in the mean time that there was a difference, as will be plain to any body that will be at the pains to read his Book. The reason why he doubted if Mons. *Richer* had given us the exact difference was, because he found that the difference observ'd by him, did not answer the numbers he brought from his own Calculation, which proceed upon a supposition that

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Gravity at all distances from the Center is the same.

But it seems the *Defender* does not see the consequence which is drawn from thence, *viz.* That Gravity must be less at the Equator than at the Poles, and therefore wishes that it were prov'd by other Experiments. It is strange and surprising, that this Author should know exactly how the Earth was made, by what Principles and Laws of Mechanism the World was framed, how the Deluge overspread the World, and what way the Mountains arose, and yet should be ignorant of so plain and easy a piece of Mechanism as this, which has not the hundredth part of the difficulty or intricacy of those which he pretends to know. Well, to convince him I will here repeat the demonstration somewhat plainer than I did in the Examination.

Let us suppose two bodies moving in two equal Cycloids; it is demonstrated by Mr. *Hugens* that the time of the descent thro' these Cycloids, is to the time of the descent thro' the Axis of the Cycloids always in a given proportion, *viz.* as the Semiperiphery of a Circle is to its Diameter; and therefore if the time of the descent or vibration in these two equal Cycloids, should be unequal, the time of the descent thro' their *Axes* will be also unequal. Now the *Axes* of the Cycloids being equal, and the time in which the Bodies move thro' them, unequal, it is evident that the

two

two forces which move these two Bodies must also be unequal ; that is, the accelerating force of Gravity in the one, will be greater than the accelerating force in the other ; or which is the same thing, (supposing the Bodies equal) the *Conatus* that the one has to go downwards, will be stronger than the *Conatus* that the other has to go downwards, that is, the Gravity of the one will be greater than the Gravity in the other.

Now this is the very case in hand ; for we find by the Observations of Pendulums, that a Body Vibrating in a Cycloid here, will perform its Vibrations in shorter time, than when it Vibrates in the same Cycloid at the Equator ; and therefore it is a demonstration that the Gravity at the Equator is not so great as it is here. Which if the *Defender* had well understood, he needed not to have troubled himself about the making of other Experiments, since there can be none that are more nice than this. For tho' the difference of time for one single Vibration be very insensible, yet this difference being often repeated, will come at last to be very sensible, and by observing it for a longer time, we may come to as great exactness as we please.

From this we may conclude, that there can be no experiments made which will more nicely determine the different Gravities at the Equator and here, than what is to be done by observations from Pendulums ; and that no
body

body will speak against such Experiments, but they who do not understand them. But however we will now consider the Experiments the *Defender* would have made to examine the different Gravities here and at the Equator.

He tells us, he would not have it made by a Balance or Scales, but by such powers as do not immediately depend upon Gravity, as Springs or other Engines, Rarefactions, or whatsoever has the force to raise, sustain, or remove, ponderous Bodies. But how does this Author know, but these Springs and Engines may change their force also at the Equator, and so be able to raise no greater weight than they will do here. Has not the weather a very great effect upon the Elasticity of all sorts of Springs, which it alters according to the dryness or dampness of the Air? And can we be sure that the same Spring in so different Climates and seasons, will preserve the same Elasticity? But granting that Springs would not alter their Elasticity in different Climates and seasons, yet the difference between the Gravity here, and that which is at the Equator is so small, (the one being to the other as 690 to 689) that the difference of their effects would be scarce sensible. For let us suppose that a weight here extended a Spring to the length of an inch, the same weight would not draw it out so far at the Equator, by $\frac{1}{690}$ of an inch, which
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quantity is so small, that we should need good Microscopes to perceive it.

The next Experiment the *Defender* would try, is that of the Barometer; for he thinks the *Mercury* should sink much lower there than with us, or indeed, to nothing if the height be comparatively so great as is supposed. It is hard to conceive, why the *Mercury* should sink lower at the Equator than it does here. I cannot suppose he concludes so, because it is lighter there than here; for upon that account it ought to rise higher, neither can I suppose that he thinks it ought to sink, because the Air is not so high there as here; for the Air turns round the Earths Axis as well as other Bodies, and therefore it must have a Centrifugal force as the rest have; and where this Centrifugal force is greatest (which is under the Equator) it will rise highest from the surface of the Earth. Since then we can see no way by which he can prove this paradox, we must leave it, and desire him to make it out in his next Book.

There are some other Experiments, that the *Defender* would try to know the exact Figure of the Earth; as for instance, He says, “ the height of the Equator should
“ make a different Horizon (as to the Hea-
“ vens, or the Earth and Sea) East and West,
“ from North and South, the Figure of the
“ Earth being a Sphere one way, and a Sphe-
“ roid the other, the Sea also must be seven-
“ teen

“teen miles deeper at the Equator than at
“the Poles. Then in reference to Rivers,
“the motion of those that rise near the E-
“quator must be swift and rapid, but very
“slow must the motion be of those that a-
“scend to it, if at all they can be suppos’d to
“climb so great a Hill.

“The great River of the *Amazons* rises
“five degrees from the Equator, yet runs up
“to the Equator with a vast load of Waters.
“*Rio de Nigro* has a longer course against
“the bent of the Earth, and crossing the
“Equator falls into the Southern Sea. The
“*Nile* in *Africk* crosses the Line, and has a
“long course on this side of it. Rivers do
“not rise higher by a natural course than
“the Fountains head, and Hydrographers
“do not assign above two foot in a mile for
“the descent of Rivers: but upon this Hy-
“pothesis, there will be fourteen or fifteen
“foot for every mile in Rivers descending
“from the Equator; which is a precipitation
“rather than a Navigable Stream. Suppose
“(says he) a Canal cut from the Equator to
“the Poles; it would be a paradox to say,
“that water would not flow in this Canal
“having fourteen or fifteen foot descent for
“every mile; but it would be a greater Pa-
“radox to suppose, that Rivers would rise to
“the Equator, and with the same celerity
“as we see they do upon an ascent of so
“many feet.

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These are the *Defender's* thoughts on this subject: it is scarce imaginable how any one should be so forward in defending the Theory, that appears so entirely unacquainted with Natural Philosophy, as this Author does. However, if it be not too late for him to learn, I will do what I can to inform him, and consider what he has said.

His first thought, that there should be a different Horizon, as to the Heavens, the Earth and the Sea, East and West, from North and South, the Figure of the Earth being a Sphere one way and a Spheroid another, is such unintelligible language as would puzzle a Mathematician to imagine, how it were possible for a Man to put such words together, with a design to mean any thing. But however, if I may humbly guess at what this incomprehensible Gentleman intends; I suppose he would say that the Section of the Earth is a Circle one way, and an Ellipsis the other.

Now I can easily demonstrate, that if the Earth were a Spheroid, any point of it would have no other Horizon than what some would have a Sphere, whose Axis is in the Axis of the Ellipse; thus, [*Fig. 15. Plate VII.*] Let A E B be an Ellipsis, E F a Tangent to it in the point E, to which erect the perpendicular E C meeting with the Axis in C at the Center C, and the distance C E, describe a Circle; it is plain, that this Circle will be touched

ouched by the streight line EF in the point E , and if both the Ellipse and Circle were turned round the Axis AB there would also be a Spheroid and a Sphere generated; both which would have the same Plane touching them in the point E , because the periphery of a Circle whose Radius is DE would be in both their surfaces, and the Ellipsis and Circle touch one another in the point E , that is, because the Horizons at E are supposed to be in the Plane which toucheth the Spheroid and Sphere in that point; both these Figures will have the same Horizons. The same thing is demonstrated of any other point.

As for his other thought, *viz.* That the Sea ought to be seventeen miles deeper at the Equator than at the Poles; he would have done well to have offered us some of his abstruse reasons why it ought to be so, for a common Reader, that is not used to his profound way of thinking, cannot easily perceive any, for he will not suppose without any arguments for it, that the Channel of the Sea is exactly of a Spherical surface, but rather think with the rest of mankind, that it is raised after the same manner that the surface of the Sea is, and is further distant from the Center at the Equator than at the Poles.

His next is a very strange thought about Rivers. For (says he) if the Earth were of a broad Spheroidical Figure, and if we should suppose a Canal cut from the Equator

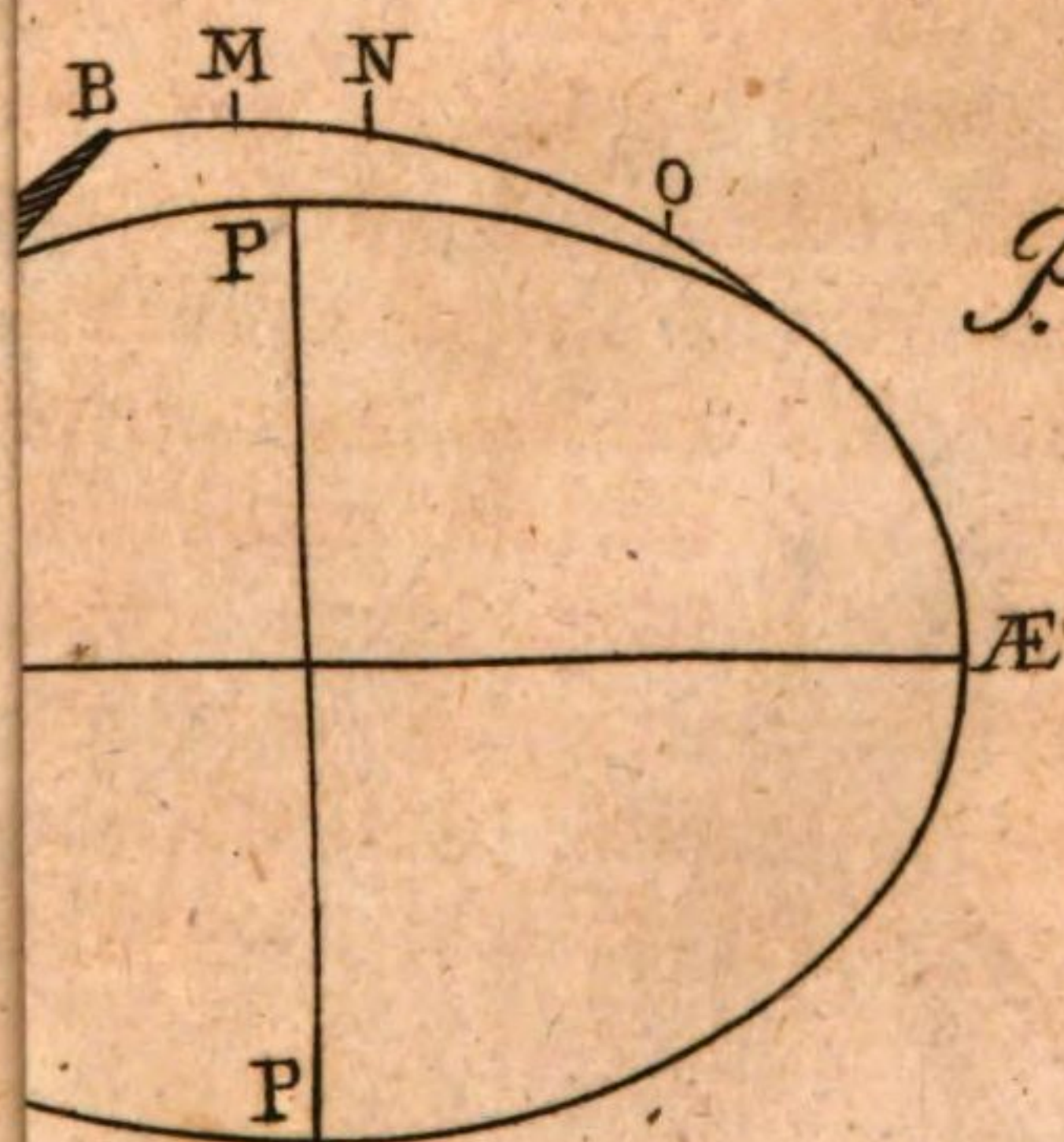
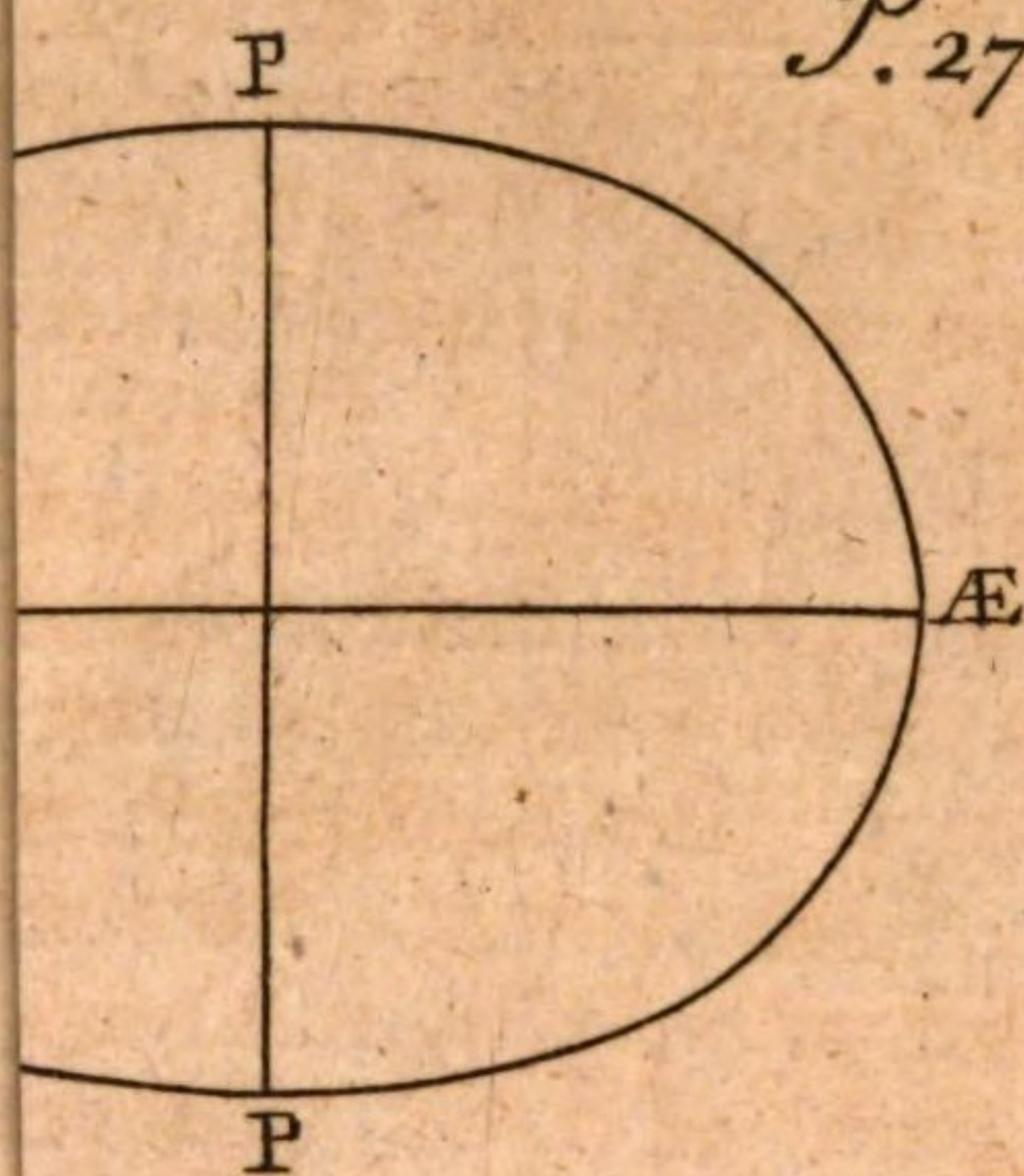
to the Poles, it were a paradox to say, that the water will not descend from the Equator to the Poles; but it would be a greater to suppose, that Rivers would rise from thence to the Equator. Well, if this be a paradox, I hope he will thank me if I teach him how to solve it.

For the greater ease and clearness, let us suppose the matter of the Earth first to have been fluid. If this matter had no Centrifugal force, it would settle its self into an uniform smooth (tho' Spherical) surface; but the Earth being turn'd round its Axis, and all the parts of it by this rotation acquiring a Centrifugal force, and those at the Equator having a stronger force to recede from their Axis than those towards the Poles; it is evident, that the fluid at the Equator would rise no higher than that towards the Poles, and the fluid would settle its self into a broad Figure; as is here represented, [*Fig. 16. Plate VIII.*] where, ÆQ represents the Diameter of the Equator, PP its Axis.

Now this being the Figure which arises from the force of Gravity joined with the Centrifugal force, it is evident, that as long as these two causes continue to act, this Figure will remain the same, and the fluid will not alter its position nor descend from Æ to P ; but that cause which first brought it into such a posture, will always preserve it in the same. Or if we should suppose this Figure
alter'd

Plate VIII

P. 276.



P. 278.

alter'd or chang'd by any external force, so that the Diameter of the Equator was made shorter; it is evident, that as soon as this external force is taken off, that the fluid being acted by the two already mentioned forces, will immediately restore its self into its former natural figure; and the parts of the fluid will never come to an equilibrium one with another, till they settle so as that the Spheroid have the same surface it had before.

Let us next suppose this fluid Spheroid to be chang'd into a solid one, all except one Channel extended from Æ to P , and as deep as you please: The fluid in this Channel having the same forces to act upon it, according to the same direction, and in the same manner, will still keep the same position, without ever changing its figure, and every part will remain in the same place that it was in before; it being indifferent to the fluid in the Channel Æ P whether the matter next it be fluid or not fluid, solid or not solid.

By this, I hope it will appear no paradox to say, that if a Channel were cut from the Poles to the Equator, that the water would not run from thence down in this Channel to the Poles. I will next make it appear no paradox, to say, that water may be made to run from the Poles to the Equator. It is well known, that (whatever be the Figure of the Earth) water will not run from the Land to

the Sea, except the Land be raised higher than the Sea, and be made to incline to it. Let us therefore suppose that $BMNO\mathcal{A}$ [Fig. 17. Plate VIII.] were the surface of the Land raised higher than the Sea, but always inclining to it till it meets with it in $\mathcal{A}$. It is plain, that whatever water is at B , will endeavour to approach to the surface $P\mathcal{A}$ as much as it can, and settle it self there in its natural figure; and because the point M is nearer to the surface $P\mathcal{A}$ than B , the water must move from B to M , but the point N being nearer to the surface into which the water does naturally affect to settle its self: it is evident, that this water will likewise move from M to N ; after the same manner and upon the same account, would the water move from N to O and from O to $\mathcal{A}$, it still coming nearer to the surface upon which it would naturally spread it self, that is, it would move from the Poles to the Equator. Thus, I hope I have made it manifest, that it is no great paradox to say, that the water will move from P to $\mathcal{A}$ or from the Poles to the Equator. I have insisted more largely upon this point, that it may appear more evident to the *Defender*; because it seems he cannot understand such reasonings, unless they are made very plain; for I had said the same things in the Examination tho' somewhat more obscurely.

Before

Before I leave this subject, I cannot but observe, that tho' our Author perhaps is very well acquainted with the Antediluvian Geography and the rise of its Rivers, yet it seems that his skill is not very great in the modern. For he makes *Nile* in *Africk* to cross the line, whereas if he had consulted the modern Geographers and their observations, he had seen that the *Nile* rises some degrees on this side of the line, as it is to be seen in *Ludolphus's* Map of *Æthiopia*.

After this fine discourse of our Authors about the ascending of Rivers towards the Equator, to conclude the argument he says, that if this difference of Pendulums were found, it will still bear a dispute from what Physical causes it proceeds. He indeed may dispute it, and perhaps will never come to know it as long as he lives, but I believe very few else will ever doubt, but that it proceeds from a greater Gravity in the one place than there is in the other; especially since it can be prov'd from demonstrative principles, that if there be two Pendulums of equal lengths that perform their Vibrations in unequal times, that the Gravity where the swiftest Pendulum Vibrates, is greater than where the slowest is. This I say can be demonstrated from most evident and Geometrical principles; and if the *Defender* does not understand them, it will be his wisest course to suspend his judgement till he has

learn't as much of the Elements of Geometry and Mechanism, as will qualify him to comprehend them.

I not only prov'd this variation of Gravity, from its effect upon Pendulums, but I also shew'd the cause of it, and that it must be so, upon supposition, that the Earth turns round its own Axis. For all Bodies that turn round an Axis, endeavour to recede from that Axis; and because at the Equator Bodies moved swiftest, the Circles there being greatest, this *Conatus* or Centrifugal force would be also greatest; now this force at the Equinoctial acting directly against the force of Gravity, (which it does no where besides) it is evident, that upon this account Gravity must be less there than any where else. Upon the account of this diminution of Gravity it must follow also, that the Diameter of the Equator will be greater than its Axis, or that the Matter at the Equator rises higher than at the Poles.

The *Defender* says, that this is agreed and own'd on all hands, in case there were no impediment to hinder the rising or retrocession of the middle parts; but (says he) the *Theorist* did believe, that the Vortex was of a shorter Diameter there than thro' the Poles, which hindred the rising of the fluid. What this impediment is, or what should occasion this straitness of the Orb at the Equator I know not; I hope the *Theorist* does not suppose

pose that there is a great iron hoop at those parts, a solid ring like that of *Saturns*, which keeps in the fluid from rising. Yet how it should be else kept in is beyond my skill to guess; I wish he would explain this more at length, that we might know what he means by it.

But let us suppose this straitness of the Orb at the Equator, and see what will follow from it; [*Fig. 18. Plate IX.*] Let *A C B* represent the Earth, first of a Spherical Figure: *E F G H* a fluid Orb of Air which surrounds it, which we will suppose straiter at *F* than at *E* and *G*; Let *A B* be the Axis of the Earth, because the matter of *C* has a greater endeavour to recede from the Center than the matter any where else upon the Earth; it is evident that this matter must press stronger upon the fluid immediately above it, than the matter at other parts can do upon the fluid immediately above them; and because the matter of the Earth is much more solid than the fluid Air, it is plain, that the *Vis motrix* or absolute force that the matter of the Earth has to recede from the Center, will be greater than the absolute force that the Air has to recede from its Center; it is plain upon this account, that the Air must yeild to it; but according to the *Theorist* the Air cannot rise higher than *F*, therefore it must recede towards *E* and *G*, and leave room to the matter at *C* to rise up to *M*; by which means it is

is evident, that (this matter thus rising at the retrocession of the fluid Air) the solid matter of the Earth must settle its self in the form of a broad Spheroid. Thus, from the *Theorists* own principles and suppositions, I have prov'd that the Earth must be higher at the Equator than at the Poles.

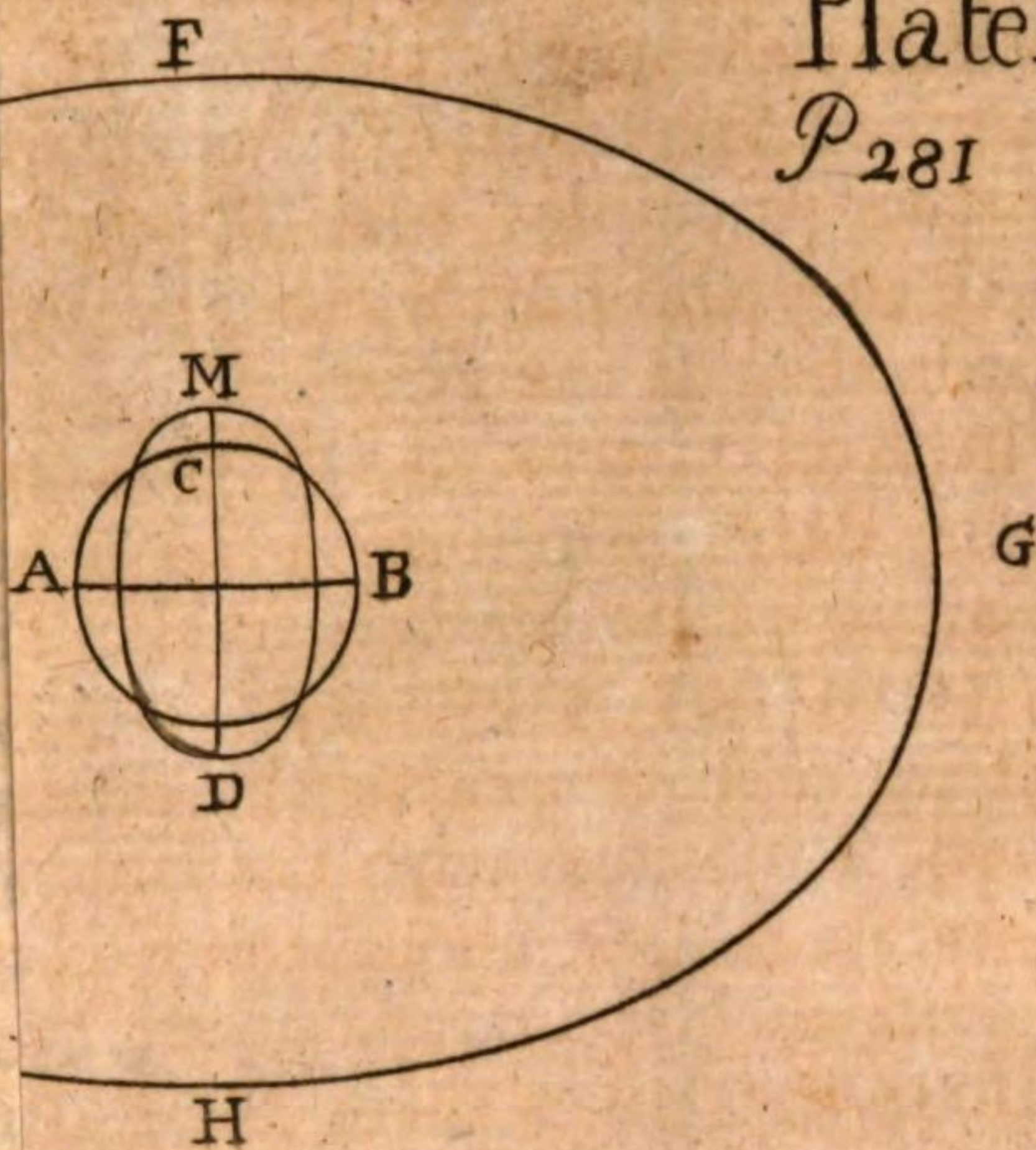
The Author tells us, that those who affirm that the Earth is in form of a broad Spheroid, will allow of no *Vortices* to the Planets; but then (says he) they must assign some other sufficient cause to carry the Planets in their Periodical motions with the same velocity for innumerable Ages about their common Center; and the Secondary about the Primary; as also what gives them their diurnal rotation, and the different position of their *Axes*.

I thought that this *Defender* had been better acquainted with the history of Philosophy for these twelve years past, than it seems he is. One would think that he had done nothing but por'd upon the Theory all this time, since he is not acquainted with what is known to every body that pretends to Philosophy now a days.

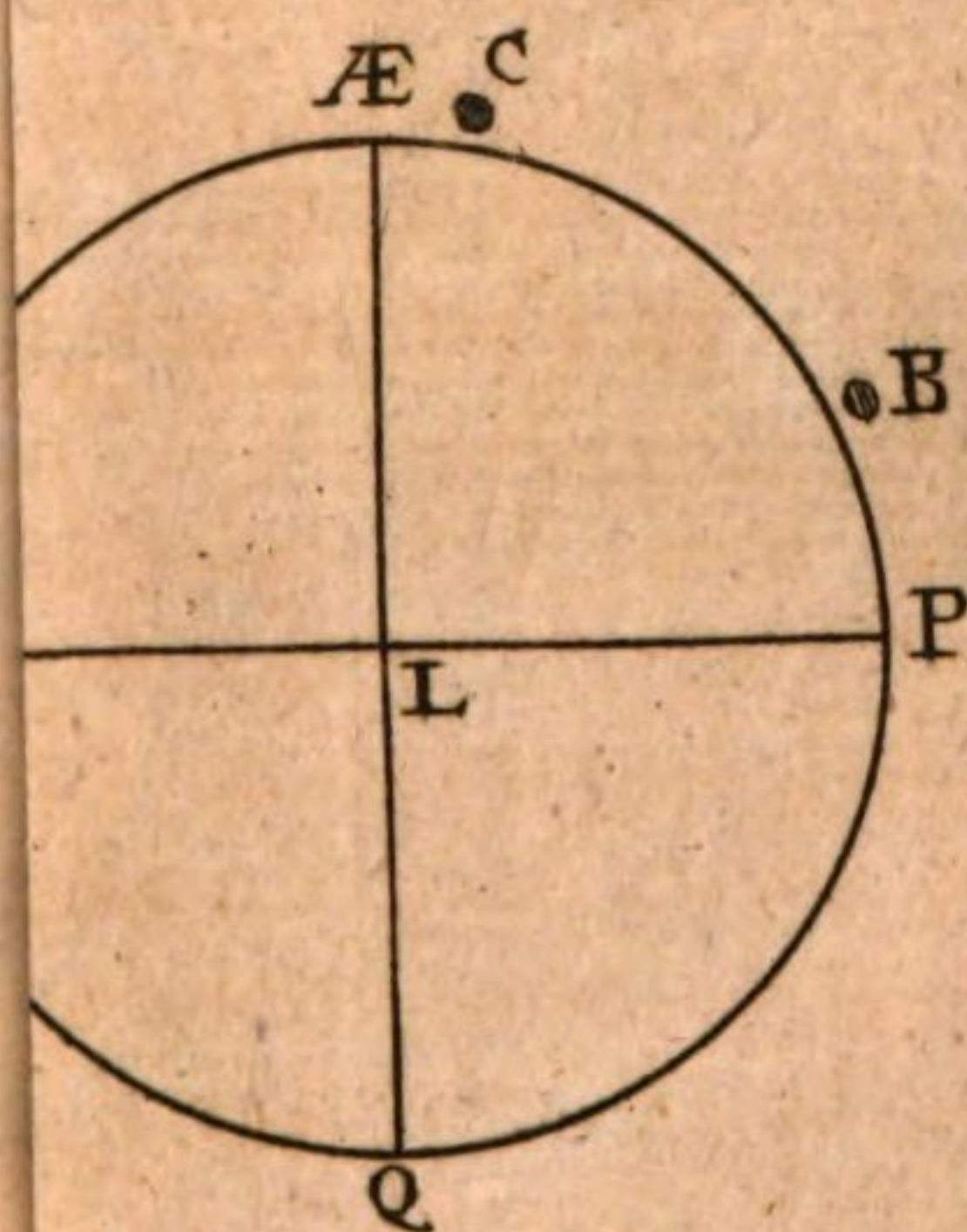
He may find several hundreds of people that can tell him, that there are other causes found for the Cœlestial motions than the *Vortices*, which will easily explain all those *Phænomena* he has just now mentioned. The causes why the Planets move in Elliptical Orbits

Plate IX

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bits are now discover'd; it is known why they move swiftest at their *Perihelia*, and slowest at their *Aphelia*. The cause of the procession of the Equinox is now no longer a mystery; and (which is for our purpose) it depends upon principles that ruin the *Theorist's* Figure of the Earth, and assert the direct contrary, making it in the form of a broad Spheroid.

The motion of the Moons *Apogee* forward and of its *Nodes* backwards, its variation, and all its other motions, are easily accounted for by the same causes, none of which could ever be made out by the *Vortices*. For by them we can't answer the first question the *Defender* puts, *viz.* What is it that carries the Planets round the Sun with the same velocity for many Ages? Nay, supposing that we were altogether ignorant of any other cause, yet it is no hard matter to prove, that the *Vortices* can never be the cause of the Cœlestial motions; and therefore there being no *Vortex*, there can be no such thing as a straitness in the Orbit at the Equator, which the *Theorist* and the *Defender* suppose. But if I should allow them both their *Vortices* and the straitness of their Orbs, I have already prov'd, that they will signify nothing to their purpose.

The *Defender* tells us, that this reasoning about the Figure of the Earth depends upon the *Theorist's* Hypothesis, that the Globe of
it

it was once fluid; and from thence he pretends to confirm the Theory: For says he) neither Figure of the Earth, oblong or oblate, can be proved from the rotation of the Earth and its Gravity, without supposing the Globe formed into that shape before it came to be loaded and stiffened with Rocks and stony Mountains; and therefore upon both Hypotheses it must be allowed, that there was such a time; such a state of the Earth when its tender Orb was capable of these impressions and modifications, and that Orb must have lyen above the waters not under them, nor radicalled to the bottom of them; and in the last place, this concretion upon the waters (says he) must have been throughout all the parts of the Earth, for there is no reason why one part of the fluid should be covered more than another; so (says he) that in effect we must suppose, that all the watery Globe was at first covered over with an Earthy concretion: Now this being admitted (says he) we have confirmed the main point of the Theory, namely, that the Abyss was at first covered over with an Orb of earth; and if we will grant him this he will compound for the rest.

He is a little too unreasonable in expecting grants of such things as are altogether precarious, and affirm'd without so much as a shew of an argument. My business was to prove, that he had deduced a wrong conclusion from his own Hypotheses and Principles; and therefore, supposing that the Globe of the Earth was once fluid, I prov'd from thence, that

that it must have settled it self into the figure of a broad Spheroid, and not of an oblong one.

But yet I demonstrated, that supposing the Earth to have been partly fluid and partly dry, as it is at present, that even in that case, the Figure of the Earth must be Spheroidical, because we observe that the Land is very nearly of the same Figure with the Sea, (only raised a little higher, that it may not be overflowed) and composes with it the same solid, but the Sea being fluid will settle its self into just such a figure, as if the whole Globe were fluid, that is (as I have demonstrated) its surface will be the same with that of a broad Spheroid; and therefore the Land which is of the same figure will be so likewise. And thus I hope I have prov'd, that whether we suppose the Earth to have been at first entirely fluid, or to have been compos'd of parts some solid and some fluid, that from either of these suppositions it follows, that the Figure of the Earth must be directly contrary to what the *Theorist* assigns.

But (says our Author) if the Earth was from the beginning in this present form, firm and solid, (as it is now) Rocky and Mountainous, then the question is, how the Parts or Regions of the Earth about the Equator, could be raised above a Spherical figure or into an oblate Spheroid; suppose then the waters raised by the circumvolution of the Earth,

Earth, how was the *Terra firma* raised, or how could it be raised by that or any such cause. These questions (says he) are no matter of difficulty to the *Theorist*, who supposes the first Earth to have covered the Waters, and to have taken their shape (whatever it was) as upon a mould.

However easy they may be to the *Theorist* I assure him that they are much easier to me, who suppose that God Almighty raised the Land at the beginning, when he form'd the Earth into the Figure it has at present, which otherwise could never have risen of its self. The dry Land therefore was raised and formed into a Spheroidical Figure by its wise Creator, on purpose that it might not be overflow'd by the Sea at the Equator, which (as I have prov'd) must of necessity have been higher there than at the Poles; and therefore if the Land at the Equator had remain'd in a Spherical Figure, no higher than that which is at the Poles, the Sea must of necessity have risen above it, and spread its self upon it like an Inundation. It was therefore wisely order'd by the Divine Providence, that not only the Sea but the Land also should be form'd into a broad Spheroidical Figure, on purpose that it might not be overflow'd with Waters.

That the Readers might observe the *Theorist's* great skill in drawing of consequences, and how well his Oval-figur'd Earth was supported

ported with reasons; I gave them his argument thus, *All bodies by reason of the Earths diurnal rotation, do endeavour to recede from the Axis of their motion, but by reason of the pressure of the Air, and the straightness of the Orb, they cannot recede from the Axis of their motion, therefore they will move towards the Poles where they will come nearer to the Axis of their motion, that is, Because all bodies endeavour to recede from the Axis of their motion, therefore they will endeavour to go to the Axis of their motion.* In answer to this, the *Defender* says, that the *Theorist* asserted, that all Bodies did *conari à centro sui motus recedere*, which I have render'd, endeavour to recede from the Axis of their motion; and by changing the word Center into Axis, of plain sense (says he) I have made non-sense; and then he is so free as to own, that the conclusion will follow from my own words, but not from those of the *Theorist*. I own, that I chang'd the word Center into Axis, not carelessly but willfully, with a design not of making it non-sense, but better sense than it was before. For we never say that a Sphere turns round about its *own* Center, for that would be plain non-sense indeed, but round about its *own* Axis; for we cannot so properly say, that a Body moves round a Center as round an Axis, unless we abstract from its Magnitude, and conceive it as a point. The reason is plain, for when any Body revolves, it is evident that every point of it
which

which does not lye in the Plane of another points Orbit, must describe a different Periphery, which must have also a different Center, so that all those Centers are placed in one line, which is therefore call'd the Axis of the Bodies motion; about which, Bodies are said to revolve much more properly than about a Center: however, this Author says, that by changing the word Center into Axis, of plain sense I have made non-sense. This Gentleman seems to be so extreamly paradoxical, that I have often suspected he must have a different method of judging what is sense or non-sense from other people, if he has it, it were but fair to shew it, that we may know when things will be agreeable to his *Criterion*, or when they will not; if he thinks it non-sense to say, that Bodies do endeavour to recede from the Axis of their motion, it is my comfort to have some good Mathematicians on my side, who think otherwise: I need only mention one of them, whose very name is enough to defend me, *viz.* The greatest Geometer and Philosopher of the Age, who uses this way of speaking very often in his *Philosophiæ Naturalis principia Mathematica*, for which he needs go no further than page 8. where it is said, *Gyrantium partes omnes conantur recedere ab Axe motus.*

But however, let us reassume the word Center, and see if the argument will appear more plausible, or seem to conclude better than

than it did by using the word Axis: *All Bodies by reason of the Earths diurnal rotation, do endeavour to recede from the Center of their motion, but by reason of the pressure of the Air and the straitness of the Orb, they cannot recede from the Center of their motion, therefore they will go towards the Poles, and move in a Circle where they will be nearer the Center of their motion.* I hope I have not now chang'd his words, but have delivered his true meaning; I leave the Reader to judge if it is not excellently well concluded, and if the connexion be not so evident, that it needs no Comment to make it out.

Now supposing, that the *Theorist* had reasoned well all this time about the Earth, and had deduced its true Figure from its true causes; yet I demonstrated, that all this will not make Rivers run from the Poles to the Equator, for a reason that I will take the liberty here to repeat, that we may compare it with the *Defenders* answer; The demonstration is this:

The Rotation of the Earth round its own Axis being still the same, the cause which thrust the water from the Equator to the Poles, will also continue the same and invariable, and by consequence it will hinder the water from returning again towards the Equator; and therefore, supposing that the Earth was formed into an Oval-figure, yet there could not be any course for the Rivers;
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for only so far would the water ascend towards the Poles, till the force which protruded it that way, came to be in *Equilibrium* with its Gravity, and there it would stop, neither ascending farther or descending again, as long as the same cause continu'd to act; that is, so long as the Earth turn'd round its own Axis in the space of twenty four hours. But if the Earth should cease to move round, then indeed, in that case and no other, would the water return to the Equator. For let the figure P Æ P Q [Fig. 19. Plate IX.] represent the Earth, P P the Poles, Æ Q the Equator, B a body upon the surface of the Earth. I think it is evident, that the body B will so far ascend towards the Poles, till the force that protrudes it that way, be in *Equilibrium* with the force that draws it to the Equator. For if at B one were greater than the other; for example, the force which draws it towards the Poles, were greater than its gravity or its tendency towards Æ , then it would still move towards the Pole, till both forces come to act equally, and there it would rest as long as these two forces continued in *Equilibrium*, which must be so long as the Earths diurnal motion lasts; now whatever Bodies either solid or fluid, are brought and lay'd upon the surface of the Earth at B, these being drawn or pusht with the same accelerating force either to the Pole or to the Equator, that the first fluid had which

which was constituted at B, the same causes continuing to act upon both, they will rest there also, and consequently will not descend to the Equator.

The *Defender* thinks he has transcrib'd this reason very briefly thus; *The same causes which cast the Abyss or the Ocean towards the Poles, will also keep the Rivers from descending from the Poles; and then he answers, that there is no parity of reason betwixt the Abyss or the Ocean, and the Rivers. We see (says he) in the flux and reflux of the Ocean, it hath not that effect upon Rivers nor upon Lakes, nor upon lesser Seas, yet the circumrotation of the Earth continues the same: He adds, That my confounding the Ocean and Rivers in the Antediluvian Earth is so much the worse, seeing there never was an Ocean and Rivers together in that Earth; while (says he) there was an open Ocean there were no Rivers, and when there were Rivers there was no open Ocean, but an inclosed Abyss; He concludes at last, That tho' I make large transcripts there and elsewhere out of the Theory, yet I do not seem always to have well digested the method of it.*

I hope the Reader will observe how unfairly this Author is pleased to deal with me, for in all the argument I have not so much as once mentioned the Ocean: but the demonstration was universal and reach't all sorts of Bodies, whether they be in the Abyss or on the surface of the Earth. My words were, that whatever Bodies either fluid or solid, if

Reflections
page last
line last.

brought and lay'd upon the surface at B, being drawn or pusht with the same accelerating force, that the first fluid had which was constituted at B, the same causes continuing to act upon both, they will rest there also, and not descend to the Equator. Where is it now that I have confounded the Ocean with the Rivers? Or is there any thing in these words, by which it appears that I have not digested the method of the Theory? There is one of this Authors acquaintance, that is pleas'd to tell us, that dissingenuity in examining the Writings of another Person falls more heavy in the construction of fair Readers, upon him that uses them, than upon him that suffers them: If it be so, this Gentleman may easily know, what these Readers will think of him.

However, it seems he thinks, that tho' none of the water return'd to the Equator while the Earth was at first fluid, and had put on its Oval-shape, yet when the first concretion was settled upon it, whatever water was after that upon its surface, would then descend towards the Equator. Why so I pray? What reason does he give for this? Had not the fluid which lay at B, the very same causes to keep it from descending to the Equator, that it had before, when the Earths surface was all fluid? Was not there the same diurnal rotation of the Earth, in the same time, and by consequence the same Centrifugal

gal force? Was there not the same pressure of the Atmosphere, and the same straitness of the Orb that was before? And in a word, every thing the same that kept it from descending in the former case, would also preserve it in this in the same position, what reason then can this Author give us for this assertion? Indeed, he offers us none; if he has any, he keeps it as a secret, which it seems he will not communicate but to his friends. I think he will do well to keep it secret for ever.

But, tho' he will neither shew us his own reasons nor answer mine, yet that we may not be altogether dissatisfy'd, he is pleased to give us a similitude to explain it: "We see *Pag. 55.*
" (says he) in the flux and reflux of the *56.*
" Ocean, (let the cause be what it will) it
" hath not that effect upon Rivers, nor upon
" Lakes, nor upon lesser Seas; yet the cir-
" cumrotation of the Earth continues the
" same." Is there any parity of reason here between the flux and reflux of the Sea, and the descent of the fluid to the Equator? Or does he think that the flux of the Sea arises only from the rotation of the Earth? If he had study'd true Philosophy but half so much as he has done the Theory, he might have known that the Tides of the Sea are caused by the action or attraction of the Moon upon it; and because one part of the Ocean (being directly under the Moon) is more attracted
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by it than the rest, the Ocean there must swell, and the water will run from the other parts of it, unto the place which is most attracted. Now in Rivers, Lakes, and narrow Seas, there being no difference of attraction in any of its parts, (they being all so narrow that the Moon cannot act stronger upon one side of them than the other) it is plain, that no part will swell more than another, and the waters will not rise higher, nor move from one place to another, by reason of this equal attraction.

Perhaps, this may be a little obscure to this Author, who as it seems does not understand the true cause of our Tides; but it not being my business to explain these things at large, I will refer him to an excellent discourse of Mr. *Edmund Halleys*, which he made to K. *James*, when he presented him Mr. *Newton's* Book of the Principles of Natural Philosophy.

He tells his Reader that I ought to have given a better notion of *Centrifugal force* than what I have done; For he quotes page 91. of the Examination, where it is said, that the Centrifugal force or that force by which a Body is drawn towards the Center; and in the next Page it is said, that by this Centrifugal force Bodies endeavour to recede from the Center of their motion, which is true, but contrary to what I said before.

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He needed not have gone so far as the 2d. line of the next page, to have found out the true notion of a Centrifugal force; for if he had repeated the words immediately following his first quotation, he might there have found it. But if he had done so he had lost his aim, and the Reader would have perceived that it was not a confusion in my notions, but only a fault of the Press. I will here repeat the sentence, that the thing may be set in its true light, *If a Body (said I) revolve freely in a Circle about a Center, as the Planets do about the Sun, its Centrifugal force, or that force by which it is drawn towards the Center, will be always equal to its Centrifugal force by which it doth endeavour to recede from the Center.* A candid Reader would have immediately imputed this to nothing else but a fault in the Printing, and instead of the first word *Centrifugal force*, he would have seen that the word *Centripetal force* ought to have been put, as the very sense would easily have directed any one that had the least acquaintance with this subject.

After this the *Defender* tells us, that I might have spar'd what I have transcrib'd from other Authors, about calculating the diminutions of Gravity made by the Centrifugal force in different Latitudes, these being needless to the confutation of the Theory. Why so I pray? Are they not to the purpose? Or do they not answer the intended design,

which was to find out by a Calculus the difference of Gravity in different Latitudes, and from thence to confirm our Hypothesis, by comparing Calculations with Observations, and seeing how the one agrees with the other? Well, but I am blam'd for transcribing them from other Authors. I hope he does not think them the worse for that; or that I ought not to make use of them as arguments against his Theory, because they were said by others. He might indeed have justly blam'd me, if I had published them as new notions or inventions of my own, and told the Word *I expected thanks for the discoveries*, as a late Author has done; but I pretended to no such thing.

It is well known that Mr. *Newton* was the first that made the discovery, and shew'd the method of Calculating the Gravity of Bodies at different Latitudes, whom therefore I mention'd as the sole Inventor. Mr. *Hugens* indeed I did not name, seeing he had the notion entirely from Mr. *Newton*, as that learned Gentleman does freely acknowledge. But after all this, I have not so much transcrib'd from these two learned Authors, as I have endeavour'd to explain their notions, and make them intelligible to Men of lower capacities.

Those two excellent and learned men, had something else to do, and matters of greater concern to mind, than to publish their discoveries

veries at large, so that every Reader might understand them. I thought therefore that it would not be altogether displeasing to the World, if I endeavoured to explain their Theorems about the Figure of the Earth, and the effects of Gravity join'd with a Centrifugal force; so that they might become intelligible to those who understand the Elements of Geometry and the common principles of Statics: and I doubted not but it would be more acceptable, because there has not (at least to my knowledge) been any discourse published of this nature in *English*.

Without doubt the Reader does now perceive, how vain, empty, and incoherent, a piece of Philosophy this Theory is; its principles are false, suppositions precarious, and the reasonings upon them, are all along so weak and ill grounded, that it is hard to think that the *Theorist* himself can give any credit to it; and yet (which is strange) he professes that he believes it more than he does the *Mosaick History* of the Creation; tho' there is this great difference between them, even supposing no inspiration in the case, that there is nothing in the account that *Moses* gives, but what is really possible; for according to him the whole was perform'd by the immediate hand of God Almighty, who needs not the help of second causes for such a work; whereas the *Theorist*, who would have it arise from Natural and Mechanical prin-

principles, always assigns such causes as are utterly insufficient for the proposed effect, and generally such as would really produce the contrary.

But if after all, the *Theorist* will still insist upon the truth of his Theory, and has no mind to prove it himself; I would advise him to find out some new *Defender*, who can understand, and consider the force of an argument somewhat better, than his last seems to have done, who (as it appears) has not so much defended the Theory, as expos'd its nakedness and his own unskilfulness.

However, since the *Theorist* has such a high opinion of his own performance, and so mean a one of the account given us by *Moses*; before I end this discourse it will not be amiss, to examine a little the notion he has given (in his *Archæologia* Book II. Chap. 8. 9.) of the *Mosaick History* of the Creation. Which in short is this, That we are not to believe the first Chapter of *Genesis* in a literal sense; but that *Moses* receded from the *Physical verity*, as he calls it, and spoke only λαοδουμαλινῶς, that is in plain *English*, there is not a word of it true, the World being neither Created nor Formed in the manner there recorded; but that his History of the Formation of Heaven and Earth was not contriv'd to be agreeable to the truth, but to the notions and dispositions of the people for whose use it was written.

Archæol.
P. 317.

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To make this out, he pretends to find many faults and incongruities in that History, which I need not now particularly consider; since there is none of them that is really incongruous and disagreeable, either to the Nature of things or the Wisdom of God, but only to his notions, and ways of thinking: As for instance, when he says (and he tells us that he speaks it with indignation) that without the greatest reproach both to the Work and its Maker, it is neither to be said or imagined, that this Earth which he stiles the very dregs and excrements of nature, should be the chief and principal part of the Creation, and the first born of every Creature, so that there should be more time allow'd for the framing and ordering of it, than what is bestowed on all the rest of the World.

Archæol.
p. 299.

However great the *Theorist's* indignation is, that he has conceiv'd upon this account, I am sure there are some that cannot read those Reflections of his upon this History, without a much greater. It may be suppos'd that *Moses* who had an immediate conversation with God Almighty, knew better what was a reproach to the World and its Maker than the *Theorist* does, and yet we find that he thought it no affront to the Divine Wisdom, not only to say and imagine such a thing, but also to write it, and that with a design, that it should be received as true by all future generations.

But

Archæol.

P. 318.

But says the *Theorist*, the Sacred Writers do often speak in a Mystical, Allegorical, or Metaphorical stile, and according to the capacity of the people, and why might not *Moses* do the same in delivering the History of the Creation. To answer this, let us consider in what cases the Scriptures are to be taken, not in a literal but in an Allegorical and Metaphorical sense, and then compare each of them with the present case, to see if there is any parity of reason between them.

First then, the Scriptures are to be understood in an Allegorical sense, when their literal meaning would imply a contradiction, either to some other place of the Sacred Writings, which is most evidently to be understood literally; or to the nature of the things spoken of; thus when God Almighty is said to have hands and feet, ears and eyes, to move and walk, and to have the affections and passions belonging to Men, all or any of these since they are a contradiction, to the Infinite perfections of the Deity, can never be understood in a literal meaning; tho' there should be still some sort of analogy between them and the thing signified. We are sure, that this consideration can have no place in the *Mosaick History* of the Creation, which most certainly does neither contradict any other part of the Scriptures, nor is there any thing said there but what is plainly possible, and can be performed by the Power of God,
who

who if he had pleas'd, could have formed the World or any part of it (how great soever) in an instant.

In the next place, the Scriptures are not to be taken in a real and literal meaning, when they speak according to the system of appearances, and the notions which we draw from our senses; Thus, when it represents the Earth plain, and as having four Corners, with the Heavens stretched over it like a Curtain. In those indeed, and in many other such like places in Scripture, it is certain, that it was the design of the Sacred Pen-men, not to speak according to the reality and nature of the things themselves, but according to the notions and opinions which people received of them from their senses; or indeed when the Sun is said to move every day from East to West, to Rise and Set, to stand still, there is no necessity of imagining that all those things are really perform'd by the Sun; but there the holy Pen-men, as all other Writers which do not concern themselves with Astronomy, speak according to the system of appearances, and as the Heavenly motions are represented to them by their senses, it being the common and receiv'd way of speaking from which we are not to recede, if we design to be understood; and even all those Astronomers who firmly believe the motion of the Earth, when it is not their business to explain the true system of the Universe,

Universe, are forced to speak in the same Dialect : and I believe we should scarce think a Man right in his wits, that in writing or speaking upon any common subject, instead of saying that the Sun rose and set, or that it came to the East or went to the West of us, would say, that our Horizon moved till it came above the Sun or went under it, or that our Horizon turned round till the East or West points of it came to be exactly under the Sun.

Now this can never be apply'd to the *Mosaick History* of the Creation, since the method of the Formation of the World could never have appeared to our senses, and without a Divine Revelation, we should have been ignorant of it to this day, and had never discover'd the order and method by which all things were form'd. *Moses* certainly wrote that discourse on purpose to give us a true notion of the Creation, and therefore was to speak of things as they were really formed, without any respect had to appearances as they would be represented to humane senses; since there was no Man then in being to whom they could have appeared, and I am of the opinion, that if he had purposely and directly wrote as much, upon the System of the World and the motions of the Heavens, as he has done upon the subject of the Creation, all those who acknowledge the Divine Authority of his writings, would have been oblig'd to believe it. The

The next case, wherein we are to recede from the literal sense in the interpretation of Scripture is, when they deliver parables; those being only contriv'd by their Writers to illustrate something wherein they would instruct the people, can never be suppos'd to be understood in a literal meaning.

This way of writing is indeed very ancient, and is of great use for informing Mankind in the precepts of Prudence and Morality, which are never so easily retain'd, or so strongly imprinted on our imagination, as when they are couched under some Fable, whose Moral is easily apprehended. But then from the nature of those Parables, and the manner of their delivery, it is easy to perceive, that their Authors never design'd they should be received as true History; all their aim was, that we should attend to the Moral, for the sake of which the Parable was contriv'd; this is plain from the Parable of *Jotham* of the Trees choosing themselves a King, and from all the Parables of our Saviour.

But the History of the Creation is a very different case from any of them; *Moses* does not give it us as a Fable, only contriv'd for the sake of some Moral meaning which he would have thereby understood, but delivers it seriously as matter of fact, which he would have us believe as firmly and truly as any other part of his History; and this a Man of integrity could never have given himself leave to do, had he not been satisfied that the History was exactly true. But

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But if the *Theorists* Hypothesis about the *Mosaical History* of the Creation were true; it seems that *Moses* must have been guilty of imposture in a very high degree, for he supposes that History to have been absolutely false, and without any foundation in the reality of things, and at the same time freely owns, that *Moses* wrote it with a design that it should be received as true, not by one Man only, but by a great and populous Nation, and that not for one Generation, but through all succeeding Ages; this I take to be strange doctrine, and no ways agreeable to the high esteem we owe either to that great Prophet, or to the Veracity of that unerring Spirit that assisted him in writing.

Pag. 320. But it is the *Theorists* opinion, that *Moses*
321. thought it necessary to give the *Jews* a *Cosmogonia*, a Theory of the Earth, each of their neighbouring Nations (as he guesses) had one of their own, which were generally erroneous and inconsistent with the true Religion; and if so, some of them might have had his Theory for ought we know; now he thinks, that without doubt the *Jews* had taken one from them, or had made one for themselves, unless they had been otherwise provided by *Moses*; * he illustrates this with a very decent similitude, if you do not get a Husband for your Daughter, she will find

* *Si nuptam non dederis filiam, ipsa sibi maritum quæret e famulis forsan aut humili plebe.*

one for her self, your Foot-man perhaps, or some one as mean.

Well, but since the *Jews* were to have a *Cosmogonia*, why should they not have been taught the true one? O says the *Theorist*, that was by no means fitting, for they were an ignorant, indocible people, and could never have been taught true and solid Philosophy, such as his own Theory is; For let us feign says he, at least (and 'tis but feigning at best) that our Theory is true, let us suppose the Primitive Earth to have been made in the same form and manner as is describ'd in the Theory; had not *Moses* spent his time well in teaching such Philosophers? Can we suppose that those Brick-makers, those who still smelt strong of the Onions and Garlick of *Egypt*, those who could not distinguish a Molten Calf from God Almighty; can we (says he) suppose, that ever they could have learnt the true principles of things, or the Laws of nature and motion? to have deliver'd those things to them, would have been to cast Pearls before Swine.

The *Theorist* may have as great thoughts of his Theory as he pleases, but it is my humble opinion, that there is very little skill required, either in the Laws of motion or Natural Philosophy, to understand it, as well as he himself does: there is no necessity of a long proof for this, since we are sure there are some, that have not only read it, but even

stood up in the Defence of it, that seem to understand as little of real Philosophy, and less of Mechanicks, than the most ignorant of his Brick-makers.

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Let us now assume the same liberty with the *Theorist*, that he has done with *Moses*, and let us suppose that the *Theorist* should get a Congregation of *Jews*, who I believe are still as dull as ever they were, and should begin to Harangue them thus.

Be it known unto you Men, Brethren, and Fathers, That this Earth which we now press with our feet, and find so firm and solid under us, was once a fluid *Chaos*; that is (that I may adapt my discourse to your low capacities) a medly, or a confused Mass of Earth, Water and Air, mixed and blended together: How it came to be so, or how long it continu'd in that state, I know as little as you do; only I am sure that it was once so, and I would have you take my word for it; at last, this disorderly Mass came to settle, and all Bodies took their place according to their weight, the great heavy Bodies fell lowest, and compos'd the innermost solid; next to them the Water took its place, and over it the Oil spread it self, above all there was a huge thick Orb of Air, full of mud and earthy particles, those by degrees fell down upon the surface of the Oil, and at first made a thick slime, which thro' time began to harden, and compose a firm and solid Crust, over
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the face of the Waters; that was able to sustain the weight of all the rest of the descending particles.

What deep reach of thought is requir'd for the understanding of this? How many, and what are the Laws of nature and motion that the *Jews* must know before they can comprehend it? in my mind the less they knew of those things, the fitter they would be to understand the Theory; at least, I am sure they would be more easily perswaded to believe it. We see now that this way of reasoning as the *Theorist* has apply'd it, is of no force against the *Mosaick History*, for his refin'd Theory if it had been true, might have been as easily comprehended by the *Jews*, as the plain and simple *Cosmogonia* of *Moses*.

The *Theorist* perhaps may think, that I have here and elsewhere treated his Theory with too much contempt and disdain; but let him consider how meanly he himself has spoke of some of *Moses's* writings, with how much scorn and derision he has rejected his History of the Creation; let him think how plainly and openly he has ridicul'd the state of Innocence and the Fall of Man; let him compare what he has said in the 7th 8th and 9th Chapters of his *Archæologiæ*, Lib. II. with the hardest Expressions in this discourse against his Theory, and I am confident he will find no reason to complain of uncivil usage.

His *Defender* 'tis true, accuses me of hard words and coarse language, in saying *that's false, that's absurd, that's ridiculous*; whereas most of the Philosophers have been forced to use the same expressions, insomuch that they became Philosophical terms, and (till the *Defender* began to write so smoothly) Men were never accounted rude and uncivil for using of them. Nay, the *Theorist* himself has been sometimes pleased to deliver himself in the same manner, and I am sure that he has handled the writings of some excellent Men with more severity, than his Theory has met with from me.

His rude treatment of *Aristotle* may be a sufficient testimony of this, whose Philosophy he never mentions but with the greatest contempt and scorn: Tho' the works of this Philosopher have been honoured with the general commendations of all the Learned thro' so many Ages, and are justly still valued by those who have the greatest reputation either for Polite or Philosophical Learning; His discourses upon Rhetorick, Poesy, and Politicks, his Logick and Ethicks, are deservedly admired as Master-pieces in their several ways; and tho' his Physiology is not without errors, yet I am sure that there is more true Natural Philosophy in his Mechanical questions alone, than in all the Theory. But if some sort of Philosophers are not acquainted with the true value of this Author, yet the general reception

ception that he has found in all the Universities of the Christian World, might one would think, have secured him from the rude insults of any private Writer.

However, the *Theorist* is not satisfy'd with exposing this great Man and his Philosophy as they come in his way, but in order, as he thinks to make him more contemptible, has given us a short View or Catalogue of his errors, If I should do so with him, and set down a Collection of all the errors that may be found in his writings, they would I am afraid, tire the Readers patience, and make a Folio almost as big as the Theory.

At last, he takes his leave of *Aristotle* in those very civil terms, *Vale Stagyrta, semper mihi eris malus Astronomus, Theologus peior, Physiologus pessimus.*

It were easy for me if I design'd to be ill natur'd, to change the word *Stagyrta* into *Theorista*, and then take my leave in the very same form: but tho' I think the *Theorist* far inferior to *Aristotle*, yet I am not for parting with him in so rude a manner; I acknowledge him to be an ingenious Writer, and if he had taken a right method and had made a considerable progress in those Sciences, that are Introductory to the study of nature, I doubt not but that he would have made a very acute Philosopher.

It was his unhappiness to begin at first with the *Cartesian* Philosophy, and not having a

sufficient stock of Geometrical and Mechanical principles to examine it rightly, he too rashly believed it, and thought that there was but little skill required in those Sciences to become a Philosopher, and therefore in imitation of *Monf. Des Cartes*, he would undertake to shew how the World was made, a task too great even for a Mathematician.

All that I now desire of him, is to spend some time in the study of Numbers and Magnitude, Astronomy and Statics, that he may be the better able to understand the force of my Arguments against his Theory, after which I doubt not but that he will easily perceive its errors, and have the ingenuity to acknowledge them. But till then, all further disputation between him and me, must needs be vain and frivolous, since true reasoning in Natural Philosophy depends on such Principles as are demonstrated in those Sciences, the knowledge of which he has not yet attained.

But Mr. *Whiston* in the first Paragraph of his Vindication, has surpriz'd me with a new

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distinction between an *Hypothesis* and a *Theory*, and tells me, That in a *Theory*, (such as he desires his should be thought) *Wit and Skill are qualifications not necessary, and very little to be considered therein.* If this be allowed, all *Theories* are unanswerable: But upon presumption that every body is not of his opinion, I shall persist in making good my first *Objections* against him.

As to the account he gives of the Origin and Progress of his Work, the Persons and opportunities that were conducing to it, I can only say, it shews too great a fondness for his *Theory*; and 'twas scarce worth his while to trouble his Reader with such minute relations about it, especially after it was, as I presume, already confuted. But however, since I have read this History of its Birth, I am less surpriz'd at the mistakes I meet with in it; since that *very Learned Friend* of his, upon whose judgment he seems chiefly to rely, (for I dare venture to say Mr. *Newton* wont engage for the truth of all his *Theorems*) has given the World reason enough to suspect him, none of the shrewdest Judges of that part of Learning.

After Mr. *Wh.* has duely inform'd his Reader, by what steps and methods he accomplish'd his wonderful performance, he tells us, That it is a little surprising, that I of all Men should in publick appear against him. His Reader may think, by this way of speaking,

ing, that there lay some special Obligations on me to be silent, tho' I declare I know none; I never enjoy'd the happiness of Mr. *Whiston's* acquaintance, and therefore cannot guess, what it is that should oblige me more than any other, to forbear publishing Remarks on his Theory. 'Tis true, I did and always shall respect and honour him, as a Learned and Ingenious Man; but I hope he does not think, that upon this account I ought to have suppressed all Objections against his Philosophy. He seems to be of opinion, that it was my duty, privately to have communicated my difficulties to him by a Letter, and not to have taken this publick method of writing Remarks on the *New Theory*. I declare, I am altogether insensible of such a duty, and I don't think, that I have transgressed the rules of civility by what I have done. It is commonly thought, that whatever any one publishes is submitted to the judgment of its Readers, and any one of them may take the same liberty in publishing Remarks upon it, that its Author did at first in proposing it to the World: And since I am perswaded that my Objections against the *New Theory*, are at least, as strong and convincing as his Reasons are for it, I cannot see, why out of a complement to Mr. *Whiston*, I should suppress them.

Mr. *Whiston* says, that I am deeply engag'd against his design, thro' a peculiar fondness

ness I seem to have for unaccountable Miracles. If I had a mind to criticise upon words, I would ask him what he means by unaccountable Miracles, and whether there be any that can be accounted for, since it is the common opinion, that what can be accounted for by natural causes, is no Miracle. However, I know no Miracles I am fond of, save those mention'd in Scripture; and at present I am only engag'd in the Defence of two of them, *viz.* The Creation and the Deluge, and a fondness for them seems not to be peculiar to me; since till this Age of World-makers, Christians have always thought them such works, as could never be produced by the Laws of Nature and Mechanism.

I know indeed that there are some, who are not only for explaining the above mentioned, but even most of the other extraordinary events recorded in the holy Scripture, by natural principles: But I dare suppose Mr. *Whiston* would not willingly be put into a Catalogue with such Authors. I could, and I think with just Reason too, tell him, that if he had not a peculiar fondness for his own Theory, he would easily perceive, that all those things which he endeavours to deduce from Mechanical principles, are not to be explain'd by such causes. But I am willing to pass by his preliminaries, and enter upon his argument.

I first objected against the *New Theory*, that the Chaos, which was the origination of our Earth, could not have been the Atmosphere of a Comet, since the one is represented as a dark caliginous Body, having darkness on the face of its Abyfs, and the other was a transparent fluid, and was enlightned, if not from its own Central Body from within, yet at least by the Sun from without. To this he Answers, that Comets cannot be changed into Planets till their return from the vast and cold Regions beyond *Saturn*; and he says, that we need not think that they will be then so vehemently hot, that they must be light also. If what he says in another place is true, I cannot but still think, that they must be hot to such a degree, that they will also be extreamly Luminous; for according to him, the heat is so great even after their return towards the Sun, that all the parts of their Atmospheres are in a violent agitation, heavy and light, dense and rare, fluid and solid parts, are jumbled and mixed together in the greatest confusion, thro' the violence of the heat. This I think, is sufficient to make us believe them very lucid likewise. But says he, solids preserve some of their heat after their light is gone. But is it credible, that the heat of the Central solid should be so great as to preserve its Atmosphere, at the distance of some hundred thousands of miles, in a continual agitation, and at the same time
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not be light? Can we suppose that it will raise vapours into its tail to the distance of many millions of miles, and after all imagine, that it is not so hot as to be lucid? This I think would be as great a paradox, as any that is to be met with among the Philosophers.

It's known, that the intenseness of light and heat is always proportional to the density of Rays that produce them, and that this density, is in all places in a reciprocal proportion to the squares of the distance of the Body, from which they proceed; and by consequence it is plain, that heat and light must be prodigiously stronger at or near the surface of the hot or lucid Body, than at a great distance from it; and therefore it is no wonder, if the heat of a solid be very sensible to a hand that is laid upon its surface; when the Eye placed at a distance from it, cannot perceive its light. But let us bring this point into numbers, that we may see it more evidently. It follows from Mr. *Whiston's* own positions, that the heat of the Central solid must be so great, even before the Comet arrives at its *Perihelion*, as to act upon the Atmosphere at the distance of 10000 miles, and from thence to raise vapours into its tail for many millions more; and therefore the intenseness of its heat at that distance, must be to the intenseness of the heat at the distance of ten miles, for example, as the square

square of ten is to the square of 100000 miles, that is, as one to 1000000000. If therefore the heat of the Central solid at the distance of 100000 miles had any sensible effect upon its Atmosphere, it must be prodigiously stronger at the distance of ten miles, and therefore cannot be supposed to be without light.

He allows the Sun to shine thro' the Atmosphere of the Comet, whilst it remains such; But then upon the Commencement of the Creation, when it began to move in a Circular Orbit, it lost its pellucidness, and became a dark and opaque fluid. How this should come to be I know not, nor can I discover, why upon the change of the Comet's Orbit from an Ellipsis to a Circle, its Atmosphere should be likewise changed on a sudden from a clear and transparent fluid, to a dark caliginous one. Immediately before the change of the Orbit, even after it had descended from the cold Regions beyond *Saturn*, he allows its Atmosphere to have been so bright and diaphanous, as that the Central solid might have been seen thro' it. It must be then a miracle and an unaccountable one too, that could have caused such an immediate darkness. It was also objected to him, that his dense and heavy fluid, could not be the Mosaical Abyfs; for it was at first dark, and afterwards enlightned, whereas his new Abyfs after it was once dark, never again became

came visible, being always covered with an opake Crust. Here he owns, that the word Abyfs is not to be restrained to his dense fluid, but that it comprehends all that heterogeneous and hitherto muddy fluid, which was beneath the Earths future surface, where the Spectator in the Historical Journal of the Creation, is suppos'd to have been.

But I desire him to tell us, whether this muddy fluid was afterwards enlightned; whether the same collection of Opake and Earthy Corpuscles which produced a darkness on the surface of the dense and heavy fluid, would not create also a thick darkness upon the surface of the muddy one; whether this darkness would not continually encrease, as those Earthy and Opake particles came closer together, and when at last they fell upon, and enclosed this muddy fluid, and form'd a Crust (according to him) of 60 or 70 Miles depth, whether they would not exclude the light from it for ever.

I had urg'd to him, that 'twas said in Scripture, *Darkness was upon the face* or the exterior surface *of the Abyfs*, and that afterwards there was light upon it. Now if Mr. *Whiston* cannot shew us clearly an Abyfs from his principles, whose exterior surface was first dark, and afterwards luminous, I hope he will grant that his Theory is not conform'd to the Mosack History.

Another

Another Argument against the Theory, was to this purpose. If the Earth was form'd by the principles of Mechanism out of the Atmosphere of a Comet, we must allow the whole subsidence to be as leisurely, and to proceed by the same steps that the violence of its heat decreases, which would not then (as he would have it) be compleated in six Years, nor indeed in as many Centuries; and the Opake parts would take so much time in descending and composing the Crust of the Earth, that the Sun would always illuminate (at least the upper Regions of its Atmosphere) as freely as it does the whole Atmosphere of Comets, while they are within our Observation. He allows this to be an Argument of good force, and to deserve consideration; and he tells us, that if Comets were observ'd to have no Atmosphere after their return from the Regions beyond *Saturn*, before they arrive at their *Perihelia* again, then indeed this reasoning were unavoidable; but seeing the contrary is evident from Astronomical Observations, it cannot affect his Hypothesis. If he had deny'd any Proposition in my Argument, or any consequence drawn from it, I should have known what reply to have made; but I cannot apprehend how this Observation upon Comets does in the least affect my Argument, nor imagine to what purpose it was brought in here, but to amuse some thoughtless Reader.

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He tells us farther, that the Laws, Properties, and Operations of Bodies, which we find established here on Earth, do not universally obtain in the Atmospheres of Comets. This I own to be an Answer, not only to this one Argument, but to all that can be said against his Theory. But may not any other Theory be defended at the same rate? Might not Dr. *Burnet* have maintained his Theory this way? And when it was objected against it, that heavy Bodies, such as Earth, Clay and Stones, could not swim upon Oil or Water, would it not have been easy for him to have said, that Bodies had then other Laws, Properties, and Operations, than they have now, and that it was at that time the Law of Nature, that the heaviest Bodies should swim uppermost, and the lightest fall to the bottom? Tho' one would think, that it were as impossible that there should be such a Law of motion, as that a Proposition in *Euclid* should be false. If the Laws of motion were arbitrary and changeable, why should the Mathematicians pretend to demonstrate them as necessary consequences from their principles? Let us suppose a *Vectis* in one of Mr. *Whiston's* Comets, and two powers apply'd to its *Brachia*, upon which they act perpendicularly, so that the powers be to one another in a proportion reciprocal to the length of their *Brachia*. It is actually impossible but these two powers must act equally

qually, the one against the other, or that one of them unassisted by any other cause; should be able to move the other against its direction: Since effects must be always proportional to their adequate causes. And yet; according to Mr. *Whiston's* position, this Law of Nature perhaps is only true in our Earth, and not in any Planet or Comet whatsoever.

By this Answer Mr. *Whiston* has granted me all that I designed to prove, *viz.* That the Earth was not form'd according to the known Laws of Mechanism; but by the efficacy of the Divine Spirit which mov'd upon the face of the Waters.

It was said in the Remarks, that there is no need of a hot Central solid, to solve the origin of Springs, and such other *Phænomena* of nature; they being better accounted for by other means. To this it is answered, that the reality of an internal heat within the bowels of the Earth, is a matter of fact, and must be accounted for whatever becomes of Springs. I always allowed an internal heat, but thought it might be accounted for without a hot internal solid; and I refer him to what has been said upon this subject, in the Examination of the Reflections on the Theory.

Mr. *Whiston* thinks, that the account I refer to for the origination of Fountains is not so universal, as to stand in no need of subterraneous vapours; But since he has given us

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no reason for this thought of his, I need say no more to it, but that I think otherwise; I am sure it is evident by Calculation, that the Vapours raised by the heat of the Sun from the Sea, are alone sufficient to serve all our Rivers and Fountains with Water. And nature never makes use of two distinct causes where one would do; for then the effect would be greater than it ought to be.

I told him, that he receded without necessity from the literal sense, in supposing, that the formation of the Sun, Moon and Stars, mention'd in the first of *Genesis*, is to be only understood of their being made visible, and of their appearing to an eye placed in the Earth. But since he desires to know my reasons for this opinion, I must tell him, that his interpretation seems to be extreamly forced, and no way agreeable with the design of the sacred Pen-men. *Moses's* narration is plain and simple, and throughout the whole, he does not affect to speak either Metaphorically or Allegorically; but he delivers it as certain matter of fact, which we are firmly to believe. He plainly mentions the Creation of the Sun, Moon and Stars, and makes the production of them a distinct days work by its self; In expressing their formation, the same word *וַיַּעַשׂ* (*and he made*) is used, that is found afterwards in the 25th verse, where there is an account given of the production of beasts; and therefore *Moses* seems to have design'd

sign'd that the word should be taken in both places in the same sense. Besides all this, it is certain, that *Moses* did not speak of things as they appeared, or would have appeared to an Eye placed in a muddy fluid, since there was no one then in being to whom they could have appeared.

From all these considerations, I think it evident, that it was *Moses's* intention to be understood in a real and literal meaning. I desire Mr. *Whiston* to consider what is said more at large upon this subject in the Examination of the Reflections on the Theory.

But after all, I do not see that Mr. *Whiston's* reasons prove any impossibility in *Moses's* account of the Creation; all that I think he proves in his long discourse is, that the plain and simple account that *Moses* gives us, is not agreeable to his Theory, to his way of thinking, or to the method by which he would have the World produced.

His Theory supposes, that the Sun upon the second day before it became visible, raised as many Vapours from the Earth, as were sufficient to fill all the Seas, Lakes, and Rivers that were in the Primitive Earth. Here, I thought he assign'd a cause no ways proportional to the effect. For since the Sun even when it shines very strongly and directly upon our Ocean, does in a whole year raise but the thousandth part of our present Ocean into Vapour, how can it be supposed, that it could raise as much

*Vindic.
pag. 9.*

Vapour in that time, as would fill the Seas, Lakes, and Rivers, of our Primitive Earth, when all the while it was not visible, but obscured by a dark and thick Atmosphere, by which the power of its beams must be extremely weakned. In answer to this, he tells us, That he does not suppose that all the Water that was in the Seas, Lakes and Rivers, of the first Earth, made above the thousandth part of our present Ocean, which he thinks might have been easily exhaled by the Sun in one half year.

Now I would have him to consider this Objection a little further, and he will find that it is not so light as he imagines it is: he knows that there must be a certain proportion betwixt Land and Sea, that the ground may be sufficiently furnished with rains and dews: for the quantity of Vapour that is raised from Water, all other things being alike, is always in proportion to the surface of the Water, and if the surface of our Sea were, *for example*, but the thousandth part of what it is now, there would in that case be raised but the thousandth part of the Vapour from it, that is at present raised from thence; and because the dry Land by such a supposition would be near double of what it is now, it follows from thence, that any particular piece of ground would not have much above one part of two thousand of the rains and dews it has at present. So that if this had been the case
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of the Primitive Earth, it must have been absolutely barren and unfruitful: But if that cannot be allow'd, it is evident, that there must have been a much greater Sea there to make it habitable, than what Mr. *Whiston* supposes.

But if after all the Antediluvian Sea had been form'd only by the raising of Vapours by the Suns heat for one half year, I do not see how it could have amounted to the ten thousandth part of our present Ocean. For it is known, that a few Clouds will more obscure the light of the Sun, and by consequence diminish its heat in the same proportion, than if nine in ten parts of its Disk were obscur'd by an Eclipse: however, I will only suppose, that its heat was but just as much diminished by the thick Atmosphere Mr. *Whiston* speaks of, (which had perfectly darkned and obscured his body for more than two years) as it would be in an Eclipse, where nine ten parts of its Disk were obscur'd; and then the number of Rays producing heat in any part, being but a tenth part of what they are now upon us, they would not raise above a tenth part of the Vapour that could be raised by the free and open action of the Sun. But the Sun when it now acts upon us freely, raises not much above one thousandth part of the present Ocean into Vapours; therefore it is evident, that in the

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other case it could not raise much above the ten thousandth part of the present Ocean, and a Sea only formed from those Vapours, would be little better than none at all.

But allowing it possible in the manner Mr. *Whiston* contends for, allowing him too, that this small stock of Waters was sufficient for the necessities of the Earth; yet after all this way of forming the Primitive Sea is by no means agreeable to the account given us by *Moses*, *Where we are told, that God divided the waters which were under the Firmament from the waters which were above the Firmament, and the waters under the heavens he gathered together into one place, and the gathering together of the waters called he Seas.* But Mr. *Whiston* tells us, the Sea was made by those Waters that were raised into Vapour by the heat of the Sun, that is according to his interpretation, by the Waters above the Firmament, which is directly contrary to *Moses's* account, who says, it was made by the gathering together of the Waters under the Firmament. It must be strange turning and wresting of words, that will bring both these ways to agree.

Besides, if the Sea were formed as the *New Theory* says it was, the dry Land must have appeared immediately upon the raising of the Vapours, whereas, according to *Moses*, it did not appear till after the formation of the
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the Sea. It is plain then, that this Theory of the Sea given us by Mr. *Whiston*, is in every circumstance as inconsistent with the holy History, as 'tis with Reason and Philosophy.

Mr. *Whiston* acknowledges, that my reasoning against his third Hypothesis of an only annual motion of the Earth before the Fall, is strong and forcible, and therefore he has been pleased here to invent another Hypothesis to support the former, by which he hopes to remove all the difficulties that were raised against it; *viz.* That the Earth did not revolve in a Circular Orbit till after the Fall, but in a moderate *Ellipse*. I shall not trouble my self with new answers as often as he thinks fit to contrive new Hypotheses, and therefore will only give this reply at present, that it will scarcely be allowed, that but one half of the Primitive Earth was habitable before the Fall, as it must be by such a supposition. We know, the more Hypotheses any Theory is clogg'd with, the more precarious it looks; such of them especially as do not naturally result from the whole Theory, but are only introduced to remove some urgent difficulty, are generally thought least of all to deserve any credit. One of the great Beauties of the Theory was, That as soon as the Comet was turned into a Planet, it had a Circle for its Orbit, and tho' this beauty is not perfectly spoiled, yet its lustre seems to

be considerably diminished by the new supposition of his new sort of Figure call'd a moderate Ellipse.

Mr. *Whiston* is pleased to take notice of a supposed mistake, he imagines I have committed, about the quantity of heat in the Primitive Earth, which I reckoned from his principles, must have been some hundreds of times greater than what is in the present. This he says, *he is sure is a plain error*, who ever it was that made him so sure of it, I am certain they have mightily deceived him. If he had taken the pains to consider, that the heat of the Sun for any small portion of time is always as a Rectangle, contained betwixt the Sine of the Angle of incidence of the Ray producing heat, and that time, and had troubled himself a little further to calculate the proportion of the quantity of heat that was in the Primitive Earth upon his Hypothesis, to that which is in our present Earth, he would have found the mistake was not on my side by his own. Every body knows, that the longer any thing is exposed to the heat of the Sun, the hotter it must be; and this is so manifest, that a great part of our heat in the Summer arises only thro' the length of time the Sun shines upon us. For if our Summer and Winter days were each of them twelve hours long, the heat in Summer would be to that in Winter, in proportion little more than three to one, (their difference
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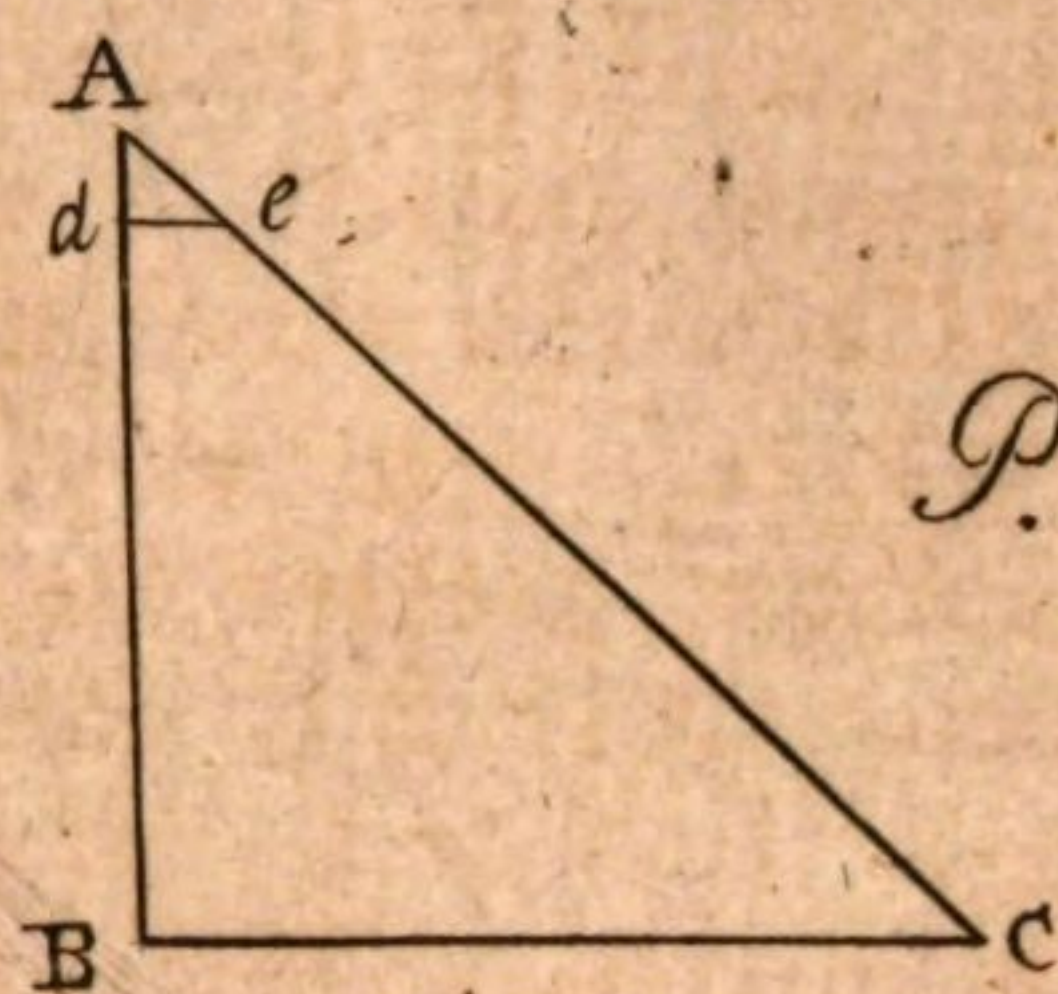
in that case arising only from the more direct action of the Sun in Summer than in Winter) whereas, in the present case, our Summers heat is to our Winters heat in a greater proportion than that of seven to one.

It was objected against the *New Theory*, that a Comet coming near the Earth could not produce any tide in the Abyfs below the Water, because it was closely shut up by a thick and solid Crust, that pressed so close upon it as to leave no space, at least, not such a considerable one, as would make room for any considerable commotion of the Waters. In answer to this, he tells us, That he wonders how I come to imagine the Orb of Earth to be so compact and solid a Sphere, as to be able to overcome the great impulse the Abyfs would make upon it, at the approach of the Comet. We may easily conceive this to be no Argument, if we consider, that a tide is nothing else but a great agitation or commotion of the Waters, arising from the attraction of some great body placed near it; and because the velocity of the Waters produced by this attraction, is at first infinitely small, their force upon any other body must likewise be infinitely small in comparison of what it will be after the Waters have acquir'd a certain determinate velocity. For as in a heavy body its velocity or force by which it endeavours to descend, is at first infinitely small in proportion to that which it acquires

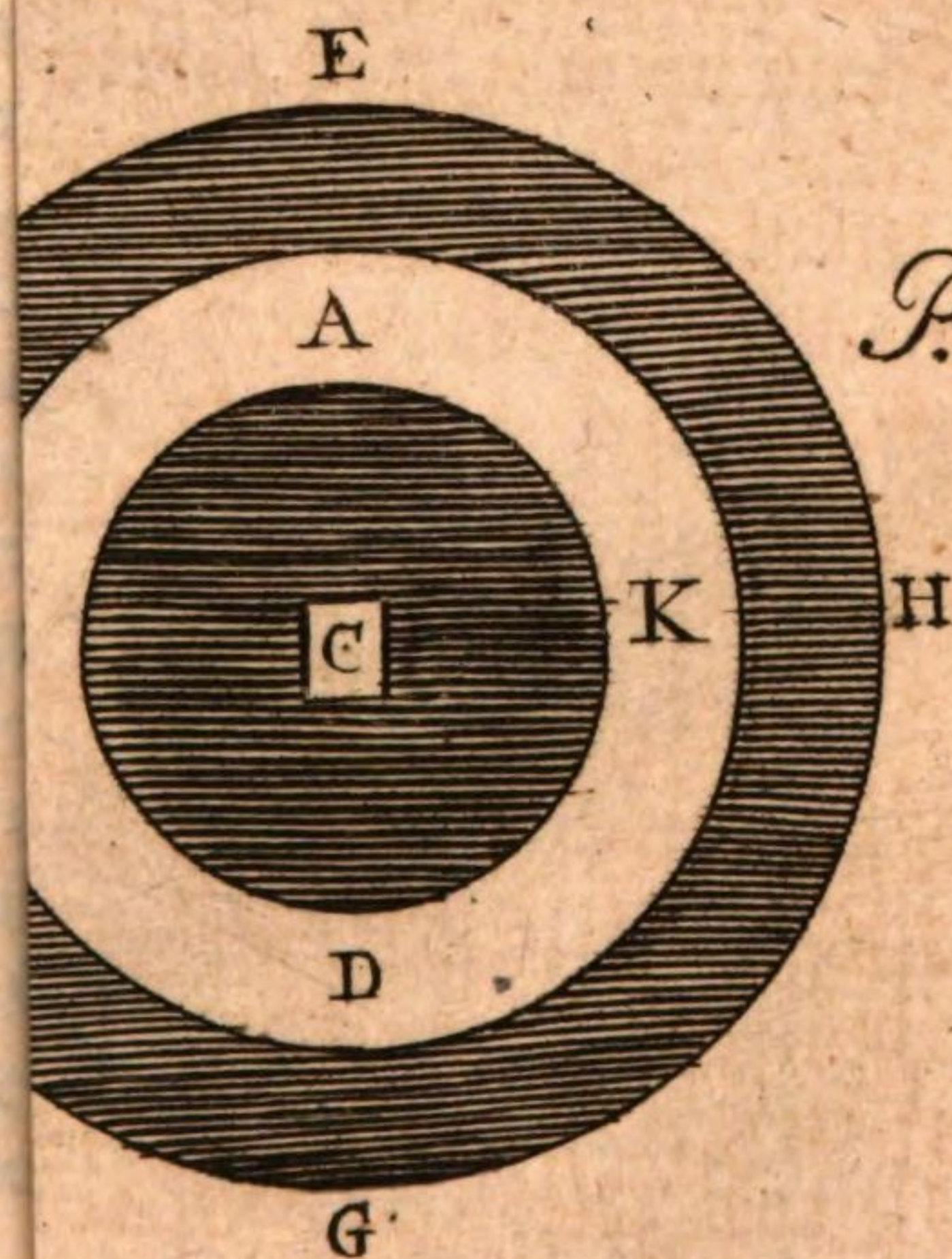
acquires in any determinate time; so here, if we suppose the velocity impressed on the fluid by the attracting body to be always in proportion to the time, and at the end of any determinate time [Fig. 20. Plate X.] AB in which it has moved, it has acquired the velocity BC : After the first instant of time $A d$, its velocity was as $d e$; and because AB is infinitely greater than $A d$, it is plain from thence, that BC must be infinitely greater than $d e$, that is, the force or impressed motion upon the fluid after it has moved in the time AB is infinitely stronger than it was in the beginning of its motion.

Let us now apply this to the case in hand; and in the present Figure [Fig. 21. Plate X.] let C represent the Central solid, $ABDK$ the dense Abyfs, $FGHE$ the outward Crust lying close upon it, and partly subsiding in it. This Crust Mr. *Whiston* imagines to be 200 miles in depth. If the Abyfs had acquired any impulse or velocity by motion, and by that force acted against the Crust, I make no question but it would be able to break it and crack it into as many pieces as Mr. *Whiston* pleases. But here there is no room left for motion, no vacuities, or void spaces: wherever the fluid is attracted, its motion will be absolutely resisted, either by the fluid next, or a dense and solid Crust immediately contiguous to it. The small cracks and fissures Mr. *Whiston* mentions, would be absolutely incon-

Plate. X.



P. 330.



P. 330.

inconsiderable, and the motion in them could not be strong enough to break or disjoyn so thick a Crust, whose parts by their own weight, and their close subsiding together, would be firmly compacted and united. Whatever the cracks and fissures were, which he imagines at first made by the Diurnal Rotation of the Earth, in the space of 1600 years, they would come to be healed and made up, so that there would not be so much as one subsiding column that can be supposed separate and disjoyn'd from the rest. And tho' we may still suppose some small fissures in the Earth, yet he asserts that they were most in the Mountains; and therefore it is impossible that the Strata could be disjoyn'd and separated from one another by them.

All the effect that would follow from this attraction is this, Both the fluid on the Abyfs and the Central solid would be attracted by the Comet; but the fluid on the Abyfs being nearer to it than the other, would be more strongly attracted; and because the solid Crust by reason of the firmness and union of its parts, cannot move faster to the Comet than the Central solid does, it is evident from thence, that it must be pressed only by the difference of attraction, or by that force by which the fluid in the Abyfs is drawn more towards the Comet, than the Central solid is; and seeing the fluid has acquired no velocity or impetus by motion, it is clear from
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what is already prov'd, and by what is more fully demonstrat'd by *Borell* in his 24 25 and 26 Chapters of his Book *De vi percussionis*; that the force of the fluid thus pressing, will be infinitely less than what it would be if it had acquired any determinate degree of velocity by motion. And since Mr. *Whiston* seems to acknowledge, that a great impulse of the fluid would be necessarily required to break and disjoyn the Crust, the small force arising from the pressure of the fluid, can never be able to produce so great an effect.

What Mr. *Whiston* says of a Floor of disjoyn'd Planks laid cross the *Thames*, that may as well be suppos'd to stop the Tide or the ascent of the Waters, as the Crust of the Earth the Tide of the Abyss, is I think no parallel case. For it is not the attraction of the Moon that is the immediate cause of the Tide in the *Thames*; but it arises solely from the check and great impulse that the Waters receive from the motion of the Sea, by which they are driven backwards with violence, and are made to ascend up the River and produce Tides.

But if Mr. *Whiston* will still assert, that the Strata or subsiding Columns were separated and disjoyn'd like so many loose Planks, (tho' it contradicts what he has said in another place*) yet granting that it was so, I shall from thence evidently demonstrate, that there could no Water arise upon that very account
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* *Vindic.*
pag. 17.

from the Abyſs or Bowels of the Earth, as ſhall be ſhown in its proper place.

The *New Theory* ſuppoſes, that the forty days rain mentioned in the Hiſtory of the Deluge, was cauſed by the vaſt quantity of Vapours that were in the Comet's tail, which being very much rarify'd and expanded, would immediately mount up again into the Air after their fall upon the Earth, and deſcend again in violent and outrageous Rains. Againſt this it was objected, that the incredible velocity with which theſe Vapours deſcended, and the great reſiſtance they met with in their deſcent, thro' the Air, together with the force by which they fell upon the ground, muſt of neceſſity have condenſed them into Water. Here he answers, that tho' the greateſt part of the Vapours ſhould be condenſed into Rain, yet 'tis hard that I will not allow many of them to eſcape the ſame, enough at leaſt to make a conſtant forty days Rain: for it is ſtrange to him, that ſo thin a Body as our Air, lying in ſo ſmall a compaſs about the Earth, ſhould have the good luck to ſtop and condenſe all and every part of ſo immense and ſwift a deſcending Column of Vapours. As ſtrange and hard as it is, yet I cannot ſee how its poſſible any ſhould eſcape being condenſed. If there were any void Canals in our Air thro' which ſome Vapours might deſcend, we might then allow him his Hypotheſis; but ſince it is evident
from

from the nature of our Air, that its impossible there should be any such empty spaces, it is certain, that there is not one of these Vapours but must meet with Air, wherever it moves in our Atmosphere, which it must therefore force out of its way; and because it is supposed to move so prodigiously swift as to descend 860 miles in a minute, the resistance it will meet with from every particle of Air must be vastly great, and must therefore necessarily condense it.

But if I should allow him that these Vapours were not condensed in their descent thro' the Air, yet to imagine that they should not be condensed when they fall with so prodigious a swiftness (as he allows them) upon the Earth, Water, or any other thing that will stop their motion, is such a fancy as needs no confutation: if they had such a strange velocity as he speaks of, they must penetrate and destroy all Humane and other Animal Bodies, so that such a shower as this one day, would have done the business of a Deluge, and there would have been no occasion for other thirty nine days Rain.

But after all this, Mr. *Whiston* grants, that the Vapours might be condensed in their fall; but yet he says, that their heat which at first rarify'd them, and had continu'd their expansion in the Comets tail, would immediately after their fall rarify them again, and raise them into new Vapour. But if so, I cannot

cannot see how this will answer the account that *Moses* gives us of the Deluge, For he tells us, that the encrease of the Waters was gradual, and produced in a great measure by forty days Rain; and that they continually encreased and prevailed upon the Earth for the space of 150 days: whereas by this Theory, the Deluge must have hapned all of a suddain; according to it, the very first day, all the Waters that came from the Comet must have fall'n upon the Earth, and by consequence the Waters that were raised from the Abyss, must have immediately ascended; so that if this Theory were true, the Deluge must be accomplished in one day and not in 150; for as to the Vapours which were raised and continued to fall for forty days, (unless the water was very scalding hot indeed) that would be very inconsiderable, and would rather diminish than encrease the quantity of Waters upon the Earth, untill they again descended in Rain.

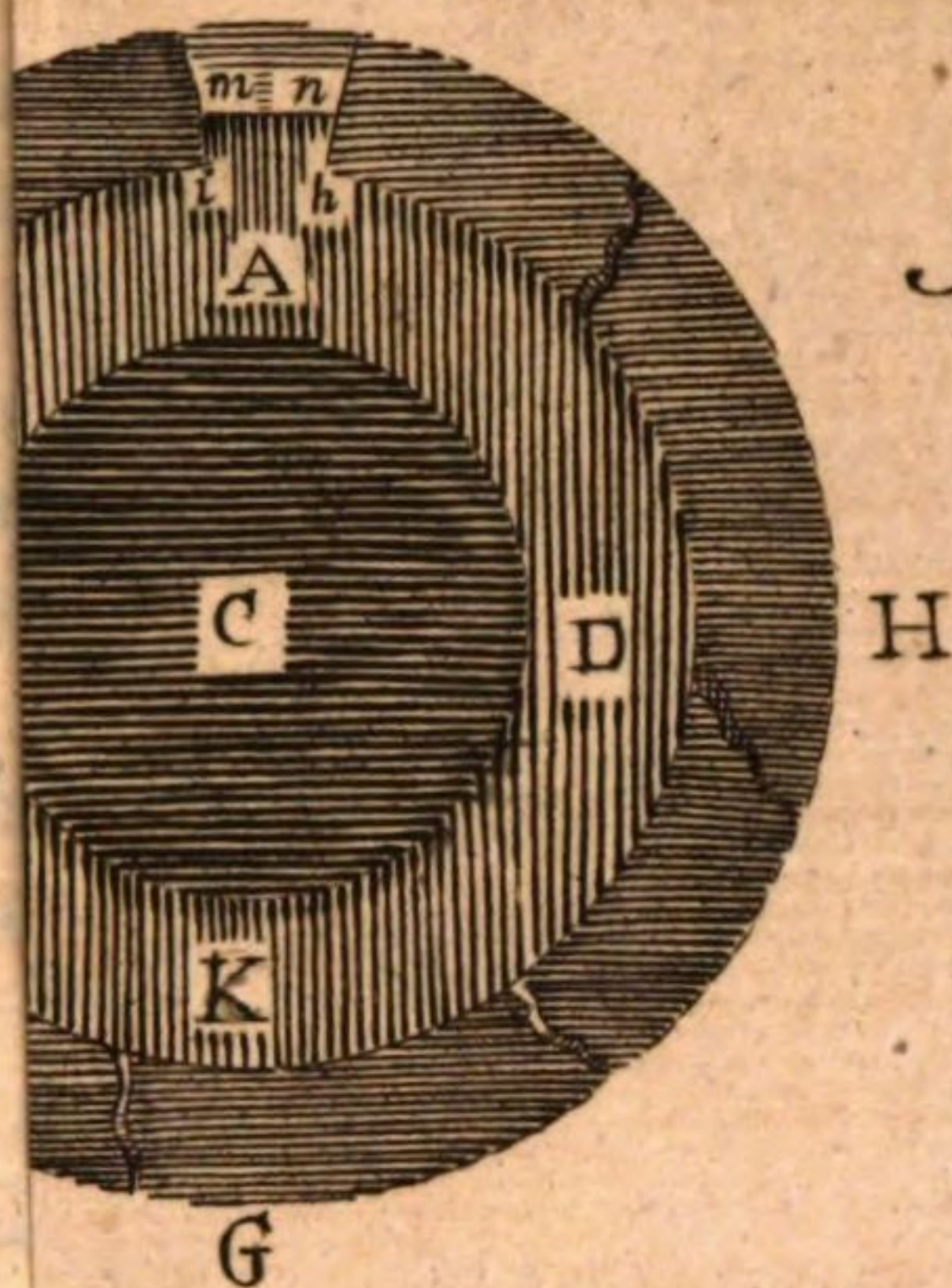
I come now to consider the way Mr. *Whiston* raises the Fluid from the Abyss. He supposes, that the great weight of the Water which lay upon the Crust, would depress it and make it sink deeper into the Abyss, and by that means force and squeeze the Fluid thro' the fissures and cracks of the Earth. But against this I positively demonstrated that no pressure of the Fluid whatsoever, could make the Crust sink deeper into the Abyss.
In

In answer to this he is pleas'd to tell me, That my demonstration supposes, either that not the water on the Earth but in the Fissures, did contribute to the raising of the Fluid thro' them, or that the several Columns had free liberty, and could subside as far as occasion should be, (which he has in his Book shewed they could not) or that a pressure from a Column specifically heavier than the Fluid, is necessary to raise it upwards. Because Mr. Whiston answers my demonstration, as if he did not rightly understand it; I will here put it into a clearer light and apply it more particularly to the present case.

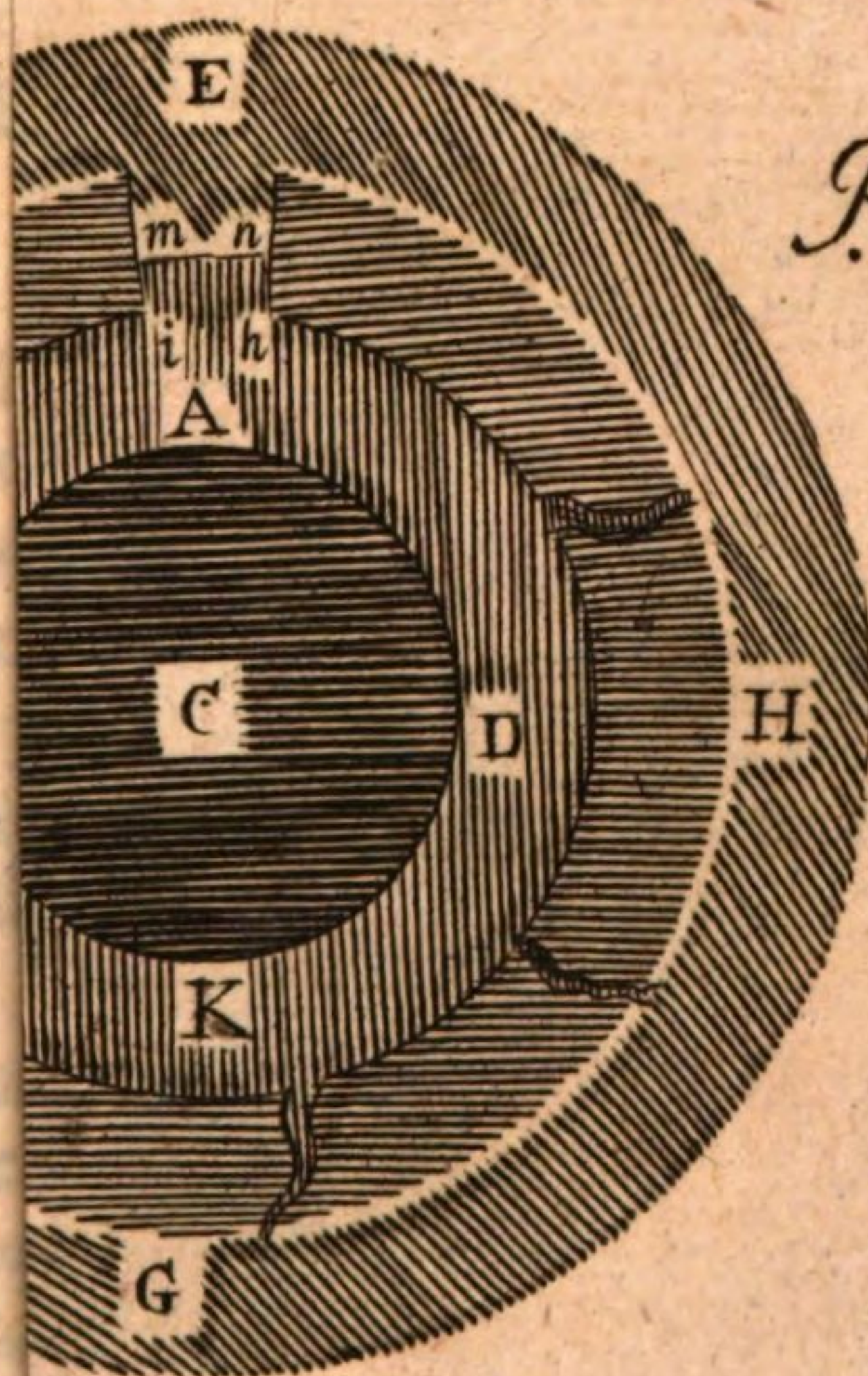
Let A B K D [Fig. 22. Plate XI.] represent the Fluid Orb of the Abyfs, E F G H the solid Crust swimming upon it, whose parts are separated and disjoined by cracks and fissures, like so many loose Planks laid cross the Thames, (and so indeed they must necessarily be, if the Diameter of the Abyfs was enlarged sixteen miles, as the Theory supposes) it is certain, that the loose Crust will be so far immersed in the Fluid of the Abyfs, or, which is the same thing, the Fluid will rise so far up within the fissure, till the surface *i k* upon which the Crust lyes, is as much pressed by the weight of the incumbent Column as the surface *i b* at the same distance from the Center, is by the weight of the incumbent fluid; that is, the fluid *m n i b* must press as much upon the surface *i b*, as the solid

Plate XI.

P. 336.



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lid Crust does upon the rest of the surface of the fluid.

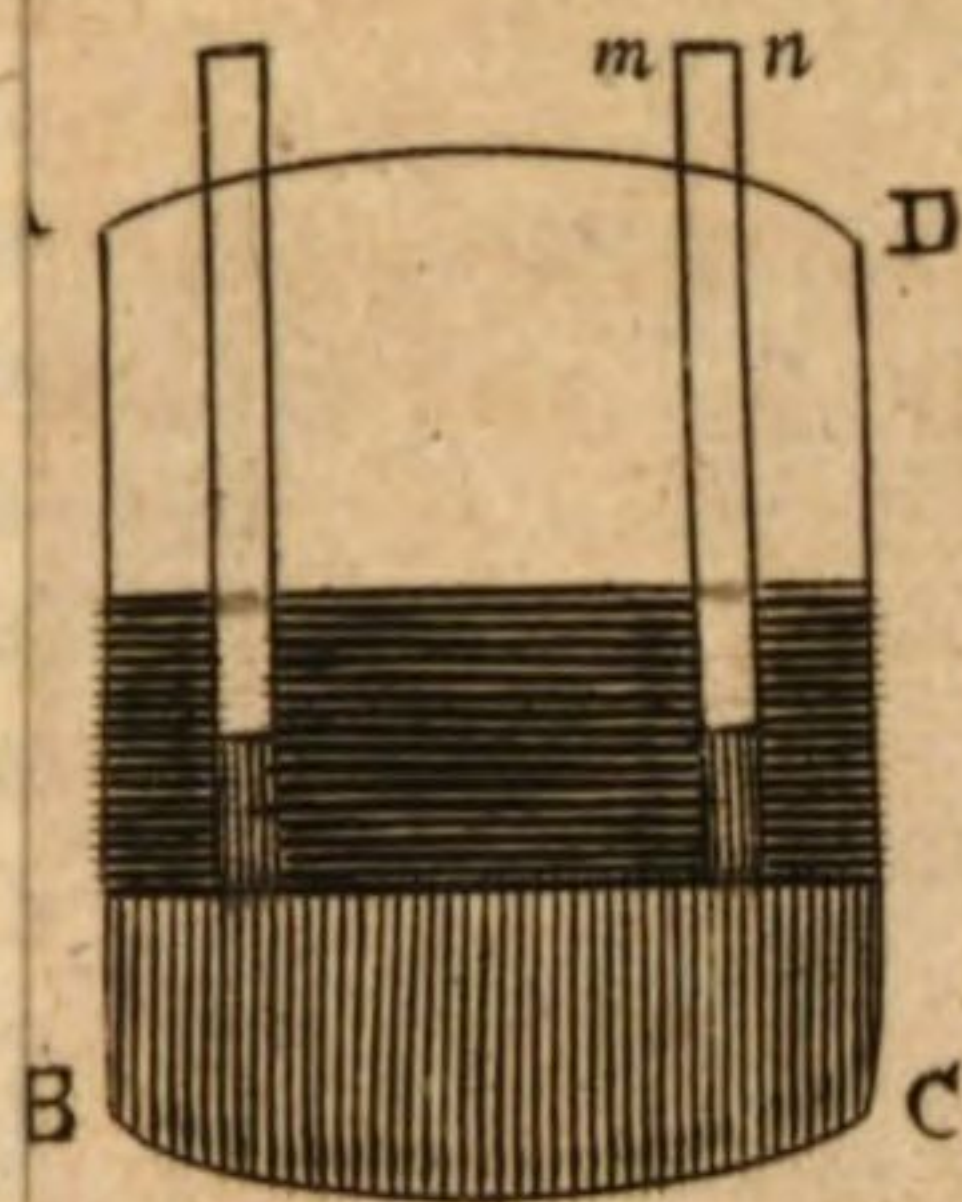
Let us next imagine all this Crust overflow'd with Water; and because Water cannot lye upon the Crust till the fissures are first entirely filled, the water must descend thro' them, and press upon the surface of the Abyfs that lyes within them. Now if the pressure of the water which lay upon $m n$ [Fig. 23. Plate XI.] the surface of the Abyfs within the fissure, were exactly equal to the pressure of the water which lay upon the Crust, the surfaces $i k$ and $i b$ being equally pressed, the parts of the fluid would still remain in the same position. But here in this case the surface $i b$ in the Abyfs being pressed with a deeper Column of water than that which presses upon the Crust, the weight or pressure of the water upon it, will be greater than the weight or pressure of the water that lyes upon the Crust, and consequently the surface $i b$ being more pressed than the surface $i k$, the fluid $m n i b$ will descend further and raise the Crust higher, and it will more emerge out of the fluid; so that we must evidently see, that by the addition of this water, the Crust instead of being depressed lower will be raised higher.

Mr. Whiston says, That this demonstration supposes that the several Columns of Earth had their free liberty, and could subside as far as occasion should be, which he has shewed in his

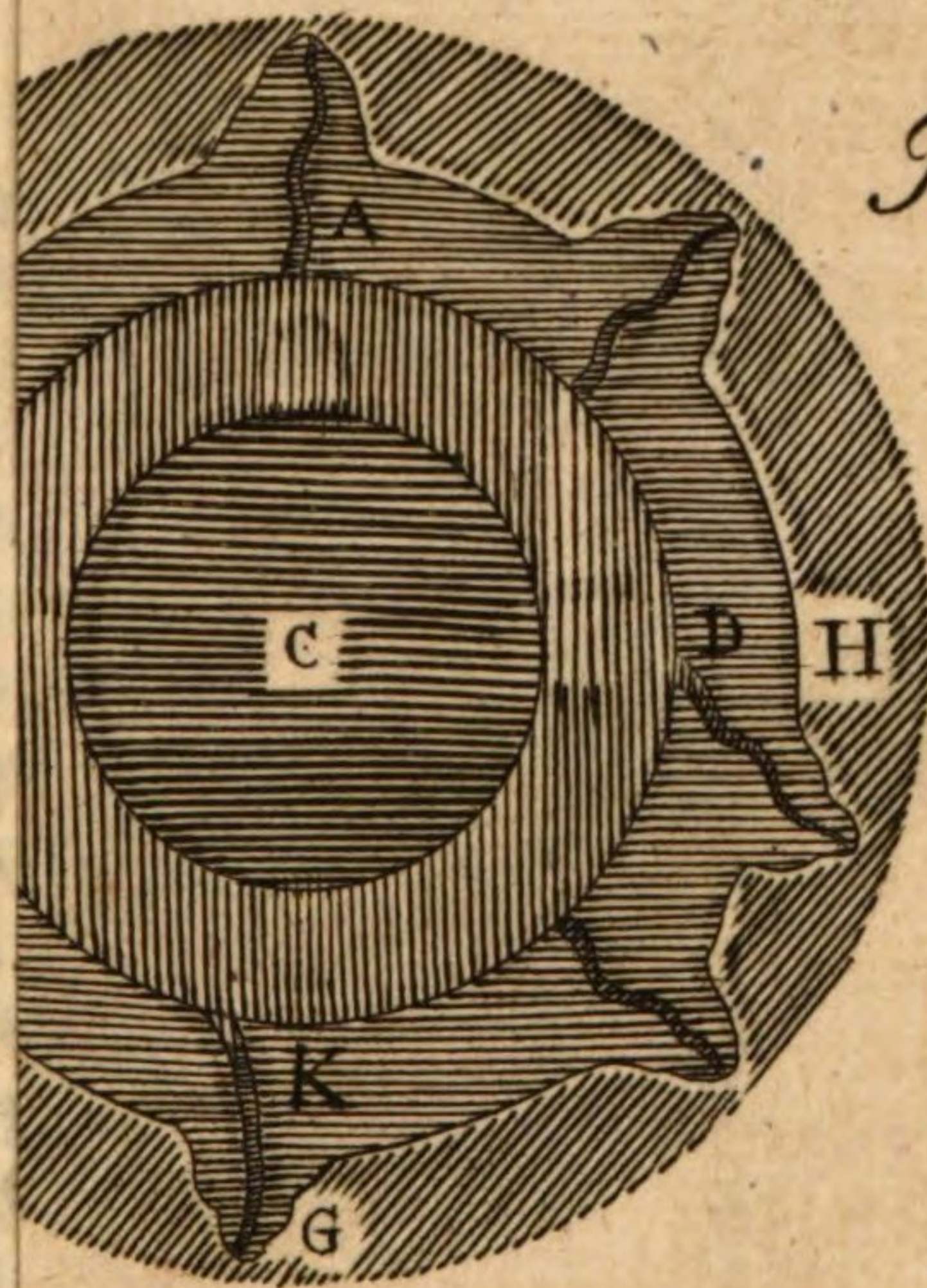
Book they could not. It seems then that he owns, that the Columns would not subside if they had their free liberty, but if they had not their free liberty to subside, then he thinks they would subside or sink deeper into the Abyss; that is in short, Those Columns would not sink deeper if there was nothing to hinder them, but if there was any thing that could hinder them from sinking deeper, then indeed they would, and must sink deeper. This is so strange and surprizing a way of reasoning, that I scarcely believe it could have come from Mr. *Whiston*. It looks much more like the reasoning of *his learned friend*. I should have thought, that if he had been left to himself to argue the case, he would have concluded, that because the Crust could not sink deeper when it was left at its liberty, or when there was nothing to hinder it; It would have certainly so much the rather not sunk further, when there was an impediment.

I know but one possible case where the pressure of the incumbent fluid can make the Crust sink deeper into the Abyss, and even in that case, I clearly demonstrated, that the fluid under the Crust could not be raised so high as to spread its self upon the surface of the Earth. But because Mr. *Whiston* has not taken any notice of this case, nor answered any thing to the Calculation that I had from thence deduced, I will here repeat it more clearly.

Plate XII



P. 339.



P. 340.

clearly. Suppose A B C D [Fig. 24. Plate XII.] a Cylindrical Vessel half full of water, in which let there be put a wooden Cylinder, which is exactly adapted to the sides of the Vessel, so that no fluid can descend between the side of the Vessel and the Cylinder. It is evident, that if there were no holes in the Cylinder, it could not in this case be any ways depressed under the surface of the water, nor could it sink into it, if never so great an additional weight were lay'd upon it; but the Base of the Cylinder would lye immediately on the surface of the fluid.

Let us now suppose this Cylinder bored with holes parallel to its Axis, then indeed it would sink so far within the fluid, till the water within the holes came to be of such a height, as to press as strongly upon the fluid under them as the solid Cylinder does upon the fluid under it, and there it would rest at the height, for example, of half the Cylinder, if the water were twice as heavy as the wood. Let us suppose in the next place, that there were long Tubes fixed in the holes to preserve the fluid, which is to be poured afterwards above on the Cylinder from running into the holes, and then let Oil or any other fluid lighter then wood, be poured on as high as the very top of the Vessel; this Oil would indeed press upon the Cylinder, and make it sink deeper into the fluid, which would rise up within the holes till it pressed as strongly
Z 2 upon

upon the surface of the water under it, as the Oil and Cylinder both together do upon the surface of the water under them. Now in this case, since the water is of a greater intensive gravity than both the Cylinders of Wood and Oil; it is evident, that it is impossible the fluid within the holes can rise so high as the top *m n*, for then the fluid which lyes immediately under that which is contain'd within the holes and the Tube, suffering a greater pressure than the rest of the fluid under the Cylinder, will immediately descend and force that which is under the Cylinder to ascend. So that tho' the solid Body must in this case sink deeper, yet it is plain, that none of the water within the Vessel can by this means be brought upon the surface.

Let us now apply this to the present purpose, and see what will be the effect. Suppose *A B K D* [*Fig. 25. Plate XII.*] a solid Mountainous Crust laid over the Abyss; and let the orifices of the fissures be supposed to be only in the Mountains, which we may conceive like so many Tubes rising up from the tops of the Mountains; and afterwards let there be laid upon this Crust any load of water whatsoever, *F G H* for example to the height of two miles.

Mr. *Whiston* says, that it is evident, that the pressure of two entire miles over each Column being so prodigiously great, must squeeze the fluid
upwards

upwards thro' the fissures, and thereby throw out the incumbent water, and perhaps it self upon the face of the Earth. But as evident as he says this matter is, I must sincerely declare, that I cannot see how any such effect can follow from a pressure after this manner. I hope Mr. *Whiston* does not act here like some new Philosophers, who, when they are to deliver some false, dark, or incomprehensible notion, generally usher it in with a speech about clearness and distinctness, and tell us, *That 'tis evident, 'tis plain, 'tis demonstrative.* But rather than suspect such dealing from him, I could suppose that the fault was in my own apprehension, if I had not demonstration on my side, to shew, that from such positions no such effect can follow. Does not he suppose this Crust to be composed of Columns of 200 miles in depth? Did not they subside close by one another, and form a solid Arch upon the Abyss according to him? If so, those fissures and cracks upon the Mountains like so many windows in a Vault, would not much weaken the strength of the Fabrick; but still it would be able to sustain a much greater weight, Would not the water that came from the Comet immediately spread it self equally over the face of the Crust? And by this every Column would be equally pressed, and therefore one could not sink deeper than another. What is it then that could force the fluid thro' the fissures? However,

let us suppose the pressure much stronger upon one place than the rest; if the solid Column upon which this pressure lay, was closely united and cemented to all the other circumambient ones, how could it be broken off from the rest? It is impossible to imagine that the weight of the waters above it could do this. But if it was before separated and disjoyn'd by the Tide on the Abyss, or any other cause, would not the water run down in the fissures which separate it from the rest, and instead of depressing, elevate the loose Crust, as I have already demonstrated?

We cannot well suppose this part which was most pressed, if it was loose from the rest, to be so closely joyn'd to them, as to leave no space for the fluid to descend: For it would be a strange chance that would make the surfaces of the Columns so exactly fitted and adjusted to each other. Besides, if they were so, because the Arch *AB* is greater than *CD*, it is impossible that in such a case it could descend or be forced downwards. But after all, if it could descend, I have already demonstrated, that none of the water in the Abyss or Bowels of the Earth, could by that pressure be raised so high as the tops of the Mountains, that it might from thence spread it self upon the surface of the Earth.

If Mr. *Whiston* does not see the evidence of this reasoning, I must leave him to be satisfy'd by his own experiment *; only instead of

* *P.* 307.

of a Cylinder of Stone or Marble, I desire him to take one of Wood; and if by pouring Oil upon it, he can raise any water from the bottom to the surface of the Cylinder, I will give over all reasoning upon this subject; but if he finds that his experiment will not succeed, (as it certainly cannot) I hope he will own that he is in an error; and then I doubt not but he will think I had reason to speak peremptorily upon this point, when I said that it was demonstratively evident, that by no sort of pressure of the incumbent fluid, the Abyss could be forced upwards to spread it self upon the surface of the Earth, which words I do not think fit to retract.

I have already considered the ways Mr. *Whiston* has taken to bring waters upon the Earth, to make a Deluge. Let us next see how dextrous he is in removing them. In my Remarks on his *New Theory*, by Calculation I shew'd, that there must have been at least twenty three Oceans of water, to drown the Earth at the time of the Deluge. One would think that it were a hard task to remove such a load of waters Mechanically. Yet he tells us, that he thinks there is no manner of difficulty in it.

In his Theory he supposes, that the waters descended thro' the perpendicular fissures and cracks, which were outlets to so great a part of them before; and by that means Saturated all the Pores of the dry Earth, that was
capa-

capable to contain mighty quantities of water. Now in the Remarks on the *New Theory*, I showed that none of the waters could descend thro' the cracks and fissures of the Earth; for they of necessity must have been all full at the time of the Deluge, since water cannot lye upon the surface of the Earth, till all the cracks, holes, and fissures in it, be first filled. This is so evident both to sense and experience, that it is beyond all contradiction true: it being as impossible to make water lye on the Earth before all its cracks, pits, and holes are filled, as it is to make a Vessel retain water, whose bottom is bored thro' with many holes.

Instead of answering this Argument, Mr. *Whiston* tells us, That *certainly the Pores and Interstices of thirty or forty miles of dry Earth, are capable of receiving three or four miles of water into them, and certainly the same fissures that permitted the ascent of the fluids from beneath before, would after the ceasing of that force, permit the descent of the waters of the Deluge, and by degrees and length of time draw them off.*

I find Mr. *Whiston* is generally most certain, where other men are most doubtful. How can he be certain, or so much as suppose, that the waters could lye above the mouths of the cracks and fissures, to the height of two miles perpendicularly, and none of them run in to fill them all the while? What new Laws of Hydrostaticks has he discovered? It is generally

rally supposed to be the nature of a fluid, to descend thro' whatever holes and fissures it can find; and 'till they be once fill'd, it is impossible it should rest above the mouths of those fissures, especially to the height of two perpendicular miles. For so high it must have been above most of those cracks, since most part of the Hills in which he supposes those fissures were, do not exceed above a miles height. Before the water could have risen to such a height, not only the perpendicular holes and fissures, but even the Horizontal ones, must have been absolutely filled.

I cannot therefore enough wonder, how he can imagine so much water forc'd thro' the Earth upon its surface, and all those cracks and fissures remaining empty all the time: I am surpriz'd to hear him tell us of *dry Earth*, that was capable of receiving vast quantities of water, for I cannot suppose an Earth that has been watered by eleven Oceans of water gushing thro' its Pores, to be very dry. Another man would rather think, that it must have been very wet, for it is not to be imagined, that so much water could pass thro' the Crust without leaving as much of it self as the Crust could hold behind it, since water rather than ascend will remain in any Pore or empty space that can contain it.

But let us now allow, that the Earth or the Crust was as dry as if there had not one drop of water remained in it; yet the Earth thro' which

which water generally can sink, is but a few feet in depth; the rest of the Crust is composed of a tough Clay, common Stone, Whinstone, Coal, Metalline Ores, and the like; and I believe he can never persuade Mankind, that there are so many Pores in such heavy, close, solid Bodies, as are capable to contain twenty two Oceans of water.

But after all, let us suppose that the fissures were empty, and that they were capable to receive the whole twenty two Oceans of water. Let us suppose that the water lay over them, without descending into them; *that is*, let us grant to Mr. *Whiston* so many impossibilities. Yet even all these suppositions will not answer the *Phænomena* of the draining of the waters from the Earth after the Deluge. This I think I can prove easily, since that according to the Mosaical account of the Deluge, the waters were remov'd from off the face of the Earth in one half year; whereas if they had been removed by the method of the *New Theory*, they could not have been drained from the Earth in many hundred years. And therefore upon this account Mr. *Whiston's* suppositions will not answer the *Phænomena*. To shew this, let us suppose the mouths of all the cracks and fissures to have been just equal to the mouths of all the Rivers in the Earth, (tho' if we consider how narrow and small they are in respect of the mouths of the Rivers, we cannot allow them
to

to have been near so much) It was proved in the Examination of Dr. *Burnet's* Theory, that all the waters that run thro' the Rivers would fill the Ocean, if it were empty, in the space of 812 years; and consequently, if at the time of the Deluge, the water descended no faster thro' the fissures, it is evident, that upon the former supposition it would be 812 years, before the Earth had received one Ocean into its Bowels, therefore it would be 17864 years before twenty two Oceans could be remov'd thro' those fissures. But let us now suppose that the velocity of the water descending, was ten times greater than the velocity of the Rivers; we shall still find, that the waters would take 1786.4 years to run thro' the fissures. So that altho' Mr. *Whiston* has been pleas'd to ridicule my fondness for Miracles, yet since all the natural causes he has assign'd, are so vastly disproportionate to the effects produc'd, he may at last perhaps be convinc'd, that the easiest, safest, and indeed the only way is to ascribe 'em to Miracles.

F I N I S.

to have been near so much) It was proved in
the Examination of Dr. Barrow's Theory, that
if the waters that ran thro' the Rivers would
fill the Ocean, if it were empty, in the space
of 812 years; and consequently if at the
end of the Deluge, the water detached no
further thro' the rivers, it is evident, that
upon the former supposition it would be
812 years, before the Earth had received one
Ocean into its bowels; therefore it would be
1784 years before twenty two Oceans could
be remov'd thro' those rivers. But let us
now suppose that the velocity of the water
descending was ten times greater than the
velocity of the Rivers; we shall still find,
that the waters would take 1784 years to run
thro' the rivers. So that also Mr. Whiston
has been pleas'd to ridicule my conduct for
thinking yet since all the natural causes he
has assign'd, are so vastly disproportionate to
the effect produc'd, he may as well perhaps
be convinc'd, that the earth, lakes, and in-
deed the only way is to ascribe 'em to Mir-

A
DISSERTATION

ON THE

*Different Figures of the
Cælestial Bodies;*

AND FROM THENCE

Some Conjectures concerning the Stars which
seem to alter their Magnitude; and con-
cerning *Saturn's* Ring.

With a Summary Exposition of the *Cartesian*
and *Newtonian* Systems.

By *Monf. MAUPERTUIS.*

C H A P. I.

*General Considerations on the Figure
of the Earth.*

THE Earth has, from remotest Ages,
been thought Spherical, notwithstand-
ing that to common appearance the Surface is
exhibited a Plane, and particularly in exten-
five

five Flats or Seas: This Appearance can deceive none but the Vulgar; Philosophers, of a Mind with Travellers agree the Earth is Spherical. On the one hand, the *Phænomena* arising from such a form, and on the other, a kind of Regularity, would not admit the least doubt of this Sphericity; and yet to consider the Thing with Care, this Notion of the Earth's Sphericity, is scarce better founded than the notion that it is flat, from the common appearance which makes it seem so; for tho' by *Phænomena* we are assured the Earth is round, they do not demonstrate to us that this Rotundity is exactly a Sphere.

In the year 1672, Mr. *Richer* going to *Cayenne*, to make some Astronomical Observations, observed that the Pendulum-piece he had carried with him, retarded considerably in respect of the Sun's mean Motion; whence it was easy to conclude that a Pendulum that vibrates seconds at *Paris*, ought to be considerably shortned to vibrate the same at *Cayenne*.

If we set aside the Resistance of the Air, (as we may without any sensible Error) the Vibrations of a Pendulum that describes Arcs of a Cycloid, or what is the same, very small Arcs of a Circle, depends upon two Causes; upon the Force wherewith Bodies tend to fall perpendicularly to the Surface of the Earth, and the length of the Pendulum. The length of the Pendulum continuing the same,

same, the time of the Vibrations can depend only on the force wherewith Bodies fall, and this time or duration becomes the longer the less this Force is.

The length of the Pendulum had not altered in the way between *Paris* and *Cayenne*; for tho' a rod of Metal lengthens with heat, and may acquire an increase of extent by being carried to the Equator; this Increase is such a trifle that it cannot be supposed the cause of such a Retardation as Mr. *Richer* observed, and yet the Vibrations were become slower; whence it must necessarily have been, that the Force whereby Bodies are urged to fall, was become less; the weight of one and the same Body was then less at *Cayenne* than at *Paris*.

This Observation was perhaps more extraordinary than any that had been proposed by this Voyage; it was plainly understood to be conformable to the Theory of Centrifugal Forces, and to be what, as we may say, ought to have been foreseen.

A secret Force, we call *Weight* or *Gravity*, attracts, urges or impels Bodies towards the Center of the Earth: this Force, if supposed to be every where the same, would make the Earth a perfect Sphere, if it consisted of a Fluid and Homogeneous Substance, and void of Motion; for it is evident that for each Column of this Fluid, taken from the Center to the Surface, to be in æquilibrium with the rest,

rest, it would be necessary for it to be of equal weight with each of the rest; and Matter being supposed to be Homogeneous, it would be necessary for these Columns to be of equal length to make them of equal weight. Now it is in the Sphere only that this Property is to be found; the Earth then would be a perfect Sphere.

But it is a Law, for all Bodies that describe Circles, to endeavour to fly off from the Center of the Circle they describe, and this their natural effort, is called their Centrifugal Force; and we know that if equal Bodies describe different Circles in equal Times, their Centrifugal Forces will be as the Circles they describe.

If then the Earth comes to revolve upon its Axis, each of its parts will acquire a Centrifugal Force, in proportion to the Circle described; that is, the greater the nearer to the Equator, this Force diminishing away to nothing at the Poles.

Now tho' it is under the Equator only that this Force would make the parts fly directly off from the Center of the Sphere, while every where else it would make them fly off only from the Center of the Circle described; yet by decomposing this Force, so much the less the farther it is from the Equator, it is plain that there is a part of it which always tends to hurry the Parts of the Fluid from the Center of the Sphere.

Herein

Herein this Force is absolutely contrary to Gravity, and must destroy a part of it, more or less, according to their proportion to each other. The Force then which urges Bodies to fall, or Gravity, being unequally diminished by the Centrifugal Force, it will not be the same every where, and will ever be the greater where the Centrifugal Force is the least.

We have seen it is under the Equator that the Centrifugal Force is greatest; and there it must consequently be, that Gravity suffers the greatest diminution; Bodies will fall then slower under the Equator than any where else; and the Vibrations of a Pendulum must be retarded in proportion as it is removed towards the Equator, and thus Mr. *Richer's* Pendulum, removed from *Paris* to *Cayenne*, which is but 4^d 55^m from the Equator, must have gone slower.

But the Force which makes Bodies fall is the very same that makes them heavy; and not being the same every where, it follows that all our fluid Columns, if they are of equal length, will not weigh every where alike; the Column that corresponds with the Equator, will weigh less than the Column that corresponds with the Pole; in order therefore for the former to be in æquilibrium with the latter, it would be necessary for it to contain a greater quantity of Matter; it ought to be longer.

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The Earth then will be higher at the Equator than at the Poles, and the more oblate towards the Poles, the greater the proportion of the Centrifugal Force; or, in other words, the Earth will be so much the more oblate, the more rapid its revolution is about its Axis, for the Centrifugal Force must encrease with this Rapidity.

But if Weight or Gravity were uniform, that is, the same at all distances from the Center of the Earth, as *Huygens* supposed, this Flatning has its Bounds. He has demonstrated That if the Earth moved about its Axis seventeen times faster than it does, it would receive the greatest Oblateness possible, insomuch that the Diameter of the Equator would be double of the Axis. A still greater degree of Rapidity in the motion of the Earth, would produce a Centrifugal Force superior to Gravity, and the Parts would disperse.

Huygens did not stop here; having determined what Proportion the Centrifugal Force has to Gravity, under the Equator, he investigated what must be the Figure of the Earth, and found that the Diameter of the Equator must be to the Axis as 578 to 577.

Sir *Isaac Newton* depending on a different Theory, and considering Gravity as the Effect of the Attraction of the Parts of Matter, does not determine the Figure of the Earth in general, and only ascertains the Proportion

tion between the Diameter of the Equator and the Axis, which he finds to be as 230 to 229.

Herman also has examined into the Figure of the Earth by the Hypothesis of a Gravity proportional to the distance from the Center, and found that the Earth must be an Ellipsoid whose Equatorial Diameter is to its Axis as $\sqrt{289}$ to $\sqrt{288}$; in which he agrees pretty nearly with *Huygens*.

None of these Measures agree with that actually taken by *Cassini* and *Maraldi*; but if from their Observations, the most famous perhaps that ever were made, it follows that the Earth, instead of being an oblate Spheroid towards the Poles, is an oblong, tho' this Figure seems to be repugnant to the Laws of Statics; we should see this to be an absolute Impossibility, before we cavil with such Observations.

In the several Calculations we just now mentioned, the Earth was considered as compounded of an Homogeneous and fluid Matter; and in this Case would most certainly be an oblate Spheroid at the Poles: but such an Homogeneity may not be in the Matter which forms the Earth; and for that Reason it is of a different Figure.

I will not here examine into the Manner how *de Mairan* thought we might be sure the Earth is an oblong Spheroid at the Poles; it has been sufficiently discussed in the Me-

Figures of the
moirs of the Academy*, and the Philosophi-
cal Transactions†.

C H A P. II.

*A Metaphysical Discourse on At-
traction.*

I Propose here to offer some probable Con-
jectures, whereby to explain how it hap-
pens that the Stars seem sometimes to increase
and decrease in Magnitude: how new Stars
seem sometimes to be lighted up in the Hea-
vens, or old ones to go out; in a word, how
a Ring like *Saturn's* may be formed around a
Planet.

These *Phænomena* are, as we may say, no
more than the Corollaries to the Problems
whereby I demonstrate the Figure which
must be assumed by a Mass of fluid Matter
revolving about an Axis, or a Stream which
circulates about an Axis taken out of itself.

These Forms depend upon the Gravity of
the parts of these Fluids, and their Centri-
fugal Force. Philosophers are perfectly a-
greed as to what concerns this last; but they

* *Memoires de l'Acad.* 1720.
No. 386. 387. 388.

† *Philo. Trans.* 1725.

vary from each other on the Subject of Gravity.

Bodies that revolve incessantly endeavour to escape in the Tangent of the Curve they describe, and this their effort is called their Centrifugal Force.

As for Gravity, some look on it as the Effect even of the Centrifugal Force of some Matter, which circulating about the Bodies towards which others gravitate, impels or forces them down to the Center of its Circulation; others without diving into the Cause, reckon it to be a property proportionably inherent in all Bodies.

Tho' the Mathematical Solutions of the Problems in this Tract, bear no relation to the nature of Gravity; yet as the Application I make of them to the *Phænomena* of Nature, depend in some sort thereon; it may be proper to touch a little on it here, to shew how far our Explications may extend, according to the different Ideas we may have of Gravity.

It is not for me to pronounce upon a doubt which divides the greatest Philosophers; but I may have leave to compare their Notions.

A Body in Motion, meeting with another Body has the Power to move it. Upon this Principle the *Cartesians* endeavour to explain every Thing, and to evince that even Gravity is but consequential thereto. Their System has, in this, the advantage of Simplicity;

city; but it must be confessed that great Objections are started against it, and occur in our Researches by this System.

Sir *Isaac Newton* not satisfied with the *Cartesian* Doctrine, which accounts for every thing by Impulsion only, discovers another active Principle in Nature, meaning that the Parts of Matter gravitate towards each other. This Principle laid down, he wonderfully unravels every *Phænomenon*; and the more we pursue him, the deeper do we dive into his System, and the more does it seem to be confirmed. But besides that the foundation of this System is less simple, in that it supposes two Principles; a Principle whereby Bodies at a Distance act upon each other, appears hard to admit.

The word Attraction has chafed the Minds of Men; many were afraid of seeing the Doctrine of occult Qualities revived again in Philosophy.

But to do justice to Sir *Isaac*, he never thought Attraction to be explanatory of the Gravitation of Bodies towards each other; he often takes notice that he used that Term only to express an Effect, not a Cause; that he applied it only to avoid Systems and Explanations; that possibly this Tendency might be caused by some subtile Matter which might emanate from Bodies, and might be the Effect of an actual Impulsion; but be it what it would, it was certainly a primary Effect, whereby

whereby might be explained all the subsequent Effects dependant thereon. Every regular Effect, may, tho' its cause be unknown, be the object of Mathematicians; because whatever is suscipient of *More* or *Less*, is within their Sphere, be its Nature what it will; and the Uses they make of it will be to the full as demonstrative, as the Applications they may make of Objects whose Nature should be absolutely known. If we were allowed to treat on such only, the Bounds of Philosophy would be strangely narrow.

Galileo, tho' ignorant of the Cause why Bodies gravitated towards the Earth, has nevertheless obliged us with a very fine and certain Theory upon this same Gravitation, and explained the *Phænomena* thence arising. If Bodies still continue to gravitate towards each other, why may we not investigate the Effects of this Gravitation, without diving into the cause of it. Our whole Business will then be to enquire whether or no it be true that Bodies have this Tendency towards each other; and if we find the thing to be a fact, let that content us for our deductions with respect to the *Phænomena* of Nature; and let us leave it to sublimer Philosophers to search into the Cause of this Tendency.

And this to me seems to be rather the best way, as I believe it in vain for us to trace up to the primary Causes of Things; and that we are unable to comprehend in what manner Bodies act upon each other,

But some of those who reject Attraction, look upon it as a Metaphysical Monster; and believe its impossibility so fully proved, that however Nature might seem to favour it, it were better to acquiesce in a total Ignorance, than to make use of so absurd a Principle: let us see therefore if Attraction, tho' considered as a Property in Matter, implies any Absurdity.

If we had perfect Ideas of Bodies; if we well knew what they are in themselves, and what their Properties; how, and in what number resident in them; we should be able to pronounce whether or no Attraction is a Property in Matter: But we, so far from being sufficiently informed; know Bodies but by some Properties only, without the least knowledge of the Subject in which these Properties are reunited.

We perceive some different Assemblages of these Properties; and this suffices for our Ideas of such and such particular Bodies; we go a step further; we distinguish different Orders or Classes of these Properties. We observe that while some of them vary in different Bodies, others of them are always the same, and these therefore we esteem as the primordial Properties, and as the Bases of the rest.

The least Attention will conclude that Extension is one of these invariable Properties. It is so universal in all Bodies, that I am apt

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to think the other Properties cannot subsist without it, and that it is their Support.

I find also that there is no body but is solid or impenetrable; I then again look upon Impenetrability to be an essential Property of Matter.

But is there any necessary Connection between these Properties? Could not Extension subsist without Impenetrability? Ought I to foresee by the Property of Extension, what other Properties should or would attend it? This is what I can by no means apprehend.

After these primitive Properties of Matter, I discover others, which, tho' not always peculiar to all Bodies, are nevertheless always peculiar to them, when in a certain State; I here mean the Property Bodies have when they move, of moving others in their way.

This Property, tho' less universal than the two already mentioned, seeing it has no relation to Bodies but when in a certain State, may however be taken in some sort, for a general Property relatively to that State, it being observable in all Bodies when in Motion.

But once more, is the Assemblage of these Properties necessary? And are all the general Properties of Bodies reducible to these? It seems to me, that it were an ill way of arguing in the Person who should so reduce them.

It would be ridiculous in us if we attempted to assign other Properties to Bodies, than Experience has pointed out to us; it would be

be more so, if upon so slender an Information of a few Properties scarce known, we presum'd to pronounce dogmatically that there is no other; as if we had the Measure of the Capacity of the Subject, when we know it but by so small a number of Properties.

We have a right to exclude no Property that is not contradictory to those we know to be in a Subject; Mobility being a Property in Matter, we may say that Immobility is not so, and Matter being impenetrable, cannot be also penetrable: identical Propositions, which are all we are allowed in this Case.

These are the only Properties we may positively exclude: But have Bodies, besides the Properties we know in them, that also of gravitating or tending towards each other; or of &c. It is to experience that we are indebted for the Knowledge of the other Properties in Bodies, and on the same must we rely for this additional Information.

I flatter my self I shall not be here stopped to be told, that this Property in Bodies, of gravitating towards each other, is more inconceivable than those every body admits. The manner how Properties reside in Bodies is what we cannot conceive. The common People are not at all surprized when they see a Body in motion communicate its Motion to others, for being used to this Sight they see nothing wonderful in it: but Philosophers who are resolute enough to decide *a priori*
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concerning what Properties are to be admitted in Bodies, and what excluded; such Philosophers I say cannot conceive the impulsive Force more conceivable than the attractive. What is this impulsive Force? How does it reside in Bodies? Who could have imagined it to have been resident therein, before he had seen the shock or congress of Bodies? The Residence of the other Properties in Bodies is not a whit more conspicuous. How comes it that Impenetrability and the other Properties are concomitant with Extension? These will be eternally Mysteries to us.

But perhaps it may be said, that Bodies have no impulsive Force. A Body communicates no Motion to the Body it strikes; it is God himself that moves the Body struck, or has established Laws for the communication of these Motions; but this is talking at random: For if Bodies in Motion have not the Property of moving others; if when one Body strikes another, this is moved only because God moves it, and has established Laws for this distribution of Motion; how shall we be able to assure ourselves that God may not have ordained the like Laws for Gravitation. The Minute we recur to an Almighty Agent, and the Negative only is considered, it should be said that such Laws imply a Contradiction; but this can never be advanced, and then is it more difficult for God to make

two

two Bodies tend or move towards each other at a distance, than to have them wait for the shock to put them in Motion.

Another Argument that may be raised against Attraction is, that the Impenetrability of Bodies is a Property on all sides allowed. This Property granted, a Body that moves towards another cannot continue in Motion, if it does not penetrate it; but Bodies are impenetrable, God then must have established some Law to reconcile the Motion of one with the impenetrability of both: Here then is a new Law become necessary at the Instant of the Congress or Shock. But for two Bodies at a distance, we see no necessity for a new Law concerning them.

This to me seems the most solid Objection that can be made to Attraction; yet tho' no answer were given to it, it proves no more than that there is no visible necessity for the tendency of Bodies; nor do I intend to make it out here, I only endeavour to evince that this same Tendency is possible.

But let us examine a little into this Matter; the Properties of Bodies are not as we have seen, all of the same Order; some of them are primordial, and common to Matter in general, inasmuch as they are always concomitant therewith, as Extension and Impenetrability.

Some of them are of a less necessary kind or Order, and are no more than the State in which

which Bodies may happen to be, or not be, as Rest and Motion.

In short there are Properties which more particularly distinguish Bodies, as Figure, Colour, Smell, &c.

If then it happen that some Properties of different Orders are in Opposition to each other (for two primordial Properties cannot be so) the inferior Property must yield, and suit it self to the most necessary, as incapable of Change.

Let us now see what must fall out when a Body moves towards another whose Impenetrability withstands its Motion. Impenetrability must unalterably subsist; but Motion which is a meer State in which a Body may be, or not be, and may be varied infinite ways, will adapt it self to Impenetrability; for a Body may move or not move, this way or that way, but it must always be impenetrably the same, and unchangeably impenetrable. Some *Phænomenon* in the Motion of the Body must then arise, consequential to the subordination of the two Properties.

But to argue in this nature against Attraction, were as if we concluded the apparent *Phænomenon* to be more necessary than the primary Properties of Matter, without considering that this *Phænomenon* subsists but in consequence of these Properties.

What we have been saying does not prove there is any Attraction in Nature, nor did I under-

undertake to prove it. My Design was only to enquire whether or no Attraction, tho' considered as a Property inherent in Matter, was metaphysically impossible. If so it were, all the most urgent *Phænomena* in nature could not obtrude it upon the World; but if it appears to be neither impossible or contradictory, we may safely enquire whether it is proved by *Phænomena* or not. It is in the System of the Universe that we are to endeavour to inform ourselves whether it be effectively a Principle in Nature; to what degree it is necessary for the Explication of *Phænomena*; or whether it be needlessly introduced to explain what may be as well explained without it.

With this regard, I presume it may not be amiss, here to exhibit a summary View of the two grand Systems which at this day divide the Philosophic World; and will begin with the System of Vortices, not barely such as *Descartes* lays it down, but with all the Improvements that have been offered in favor of it.

I shall then proceed to Sir *Isaac Newton's* System, so far as I shall be able, by divesting it of the Calculations which so display the wonderful Harmony of all its parts, and give it such a convincing Force.

C H A P. III.

*The Motion of the Planets explained
by Vortices.*

D*Escartes* to account for the Revolutions of the Planets around the Sun, supposes them imerged in a Fluid, which circulating around that glorious Star, forms the vast Vortex which sweeps them along, just like a Vessel when left to the Tide of a River.

This Explanation, so simple at first Sight, is liable to great Objections, when duly considered.

The Planets indeed move round the Sun, but in such a manner as every body now knows.

The Orbits of the Planets are not Circles, but Ellipses, in whose Focus the Sun is. One of the Laws of their Revolution, is, that they go thro' equal Area's in equal Times, and hence the Acceleration of the Planets as they draw nearer and nearer to the Sun; for the right Lines produced from the Place of the Planet to the Sun, being then shorter, the Elliptic Arcs gone through by the Planet must be proportionably larger, for the Planet to describe an Area equal to the Area it describes at a greater distance from the Sun, when

when the Lines produced as above said are longer.

All the Planets, we know any thing of, observe this Law; not only the primary Planets that revolve around the Sun, but the secondary Planets also that revolve about some primary, as do the Moon, and the *Sattelites* of *Jupiter* and *Saturn*; but here the Area's which are in proportion to the times, are Area's described about a primary Planet, which to its *Satellites* is as the Sun to the primary Planets. And hence the Orbit of a Planet, and the time of its Revolution being known, you may at every Instant find the Place of the Planet.

Another Law gives you the Analogy between the periodical Time of each Planet, and its distance from the Sun; a Law as scrupulously obeyed as the former, which is that the Time a Planet takes in going round the Sun, is as the square Root of the Cube of its mean distance from the Sun.

This Law also extends to the secondary Planets; but in this Case the periodical Times and Distances, are to be taken from the primary Planets respectively. By this Law, the distance of two Planets from the Sun, and the periodical Time of the one being given, you may investigate the periodical time of the other; or the periodical Times of two Planets, and the distance of one of them being given, you may have the distance of the other.

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These two Laws being laid down, it is not only sufficient that we say in general why the Planets move round the Sun; we must also shew why they observe these Laws; or at least what we advance, on their Motion, must not be contradictory to these Laws.

Seeing that both the distances of the Planets from the Sun, and their periodical times are different; the *Vortex* cannot every where be of the same Density, and the times of its Revolution not the same every where.

As each Planet describes equal Area's in equal Times, it follows that the Beds of the *Vortex* Matter have their Velocities in a reciprocal Proportion to their distances from the Center.

But, because the periodical Times of the several Planets, are in proportion to the square Roots of the Cubes of their distances from the Sun, it follows that the Velocities of the same Beds are in a reciprocal Proportion to the square Roots of their distances.

If one of these Laws be ascertained, the other becomes necessarily incompatible. If we would have it that the Beds of the *Vortex* have the Velocities necessary for each Planet to describe equal Area's about the Sun in equal times; it must follow, for Example, that *Saturn* would perform his Revolution in 90 Years, which is quite contrary to Experience.

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If on the other hand we would indue the several Beds of the *Vortex*, with the Velocities required to make the Periodical Times proportional to the square Roots of the Cubes of the distances; we shall find that the Area's described by the Planets around the Sun will cease to be equal in equal Times.

I do not here speak of the Objections, raised against the *Vortices*, which do not seem invincible: nor do I say any thing of that made by Sir *Isaac Newton*, by supposing with *Descartes*, that the *Vortex* receives its Motion from the Sun, who revolving about his Axis, would communicate this Motion from Bed to Bed, to the utmost verge of the *Vortex*. Sir *Isaac* had, by the Laws of *Mechanics* sought after the Velocities of the several Beds, and found them to be very different from those which quadrate with the Rule of *Kepler*, concerning the proportion between the Periodical times of the Planets, and their distances from the Sun. *Bernoulli*, in his fine Dissertation which won the Academy's Prize, in the Year 1730, has shewn that Sir *Isaac* did not sufficiently consider several Things which alter the Calculation. It is true indeed that the said Thing duly considered, the Velocities of the several Beds are found to differ from what they ought to be for the completion

pletion of this Law, but they come somewhat nearer than before.

But let the Motion of the *Vortex* proceed from what Cause soever, the Velocities of the Beds might be brought to agree with one of the Laws we have mentioned; but never with both at the same time; and yet these two Laws are the one as inviolable as the other.

The more Learned have endeavoured to solve this Matter; but *Leibnitz* * in particular could only say that, throughout the Orbit described by each Planet, there must be a Circulation he calls *Harmonic*; that is a certain Law of Velocity to make Planets observe the Law of describing equal Area's in equal Times; and that at the same Time there must throughout the whole extent of the *Vortex* be a different Property of making the Planets observe the Proportion between their Periodical Times, and their distances from the Sun: This is all one of the greatest Men of the Age could say in Defence of the *Vortician* System.

* *Vide*
Act. Erit-
dit. 1689.
p. 82. &
1706. p.
446.

Bulffinger, in the Dissertation which won the Prize in 1728, acknowledges and better demonstrates the necessity of this different Law in the Fluid which sweeps away the Planets. But it is hard to admit of these different circular Beds moving with independant and broken Velocities.

There is another Objection to this System which is not of less weight: The several Beds of the *Vortex*, are nearly of the same Densities with their respective Planets, for each of the Planets swims in its particular Bed; and these Beds move with prodigious Rapidity; yet we see that the Comets traverse them, without any sensible alteration of their Course. The Comets themselves may as likely be hurried along by Fluids, which may circulate athwart the Fluids which convey the Planets, without confounding, or disturbing their Course.

Let us now proceed to the Doctrine of Gravity according to this System.

C H A P. IV.

Of the Gravitation of Bodies towards the Earth, by Vortices.

ALL Bodies fall, when not sustained, and tend to the Center of the Earth.

To explain this *Phænomenon*, *Descartes* supposes a *vortex* of Fluid Matter to circulate with great velocity round the Earth, in a direction parallel with the Equator. It is well known that when a Body describes a
Circle,

Circle, it endeavours to fly off from the Center; every part therefore of this Fluid must have this centrifugal Desire or Endeavour to fly off from the Center of the Circle described. If then they meet with a Body which has not, or has less of this centrifugal Property, the Body must yield to their Effort; and the parts of the Fluid having always more of this centrifugal Force than the Body, must successively take its place, till they have forced it down to the Ground.

This general Doctrine of Gravitation is also liable to great Objections, the chief of which are these,

HUYGENS Objects

1. If the motion of such a *Vortex* was rapid enough to drive Bodies so forcibly downwards, it ought to give them some horizontal Impulse, and hurry them along in its own direction.

2. If the cause of Gravity be attributed to a *Vortex* that moves parallel to the Equator, Bodies would not fall towards the Center of the Earth, but must fall perpendicularly to the Axis. The fall of Bodies being effected by the centrifugal force of the *Vortex* Matter, and that force tending to remove the said Matter from the Center of every Circle it describes, it must every where impel Bodies towards the Center of

every particular Circle; and so Bodies instead of falling towards the Center of the Earth, would tend perpendicularly to the Axis; but neither of these happens. It is ever observed that the Tendency of Bodies is invariable, and that they fall perpendicularly to the Surface of the Earth.

It has been the good Fortune of the *Cartesian* System to meet with able Defenders; Mr. *Saurin* has given a very ingenious answer to these Objections.

Let us see how *Huygens* supplies the Defects he discovers in the *Cartesian* System. Instead of making the ætherial Matter move all around the same Poles, he supposes it to move in all Directions in the spherical Space that contains it; and these Motions crossing each other till they become Circular, the ætherial Matter will at length come to move in spherical Surfaces of all Directions.

This Hypothesis laid down, frees the *Vortex* from two Objections made thereto.

1. The ætherial Matter, the Cause of Gravity; circulating in all Directions, it cannot impel Bodies Horizontally like the *Cartesian Vortex*; because the Horizontal impulse it receives from every Surface of this Matter, is destroyed by a contrary Impression.

2. It is plain that in this Case Bodies must fall towards the Center of the Earth; because the ætherial Matter, which circulates in each spherical Superficies, impelling them
towards

towards its own Axis, they must tend towards the Intersection of all these Axes, which is the Center of the Earth.

This System accounts for the *Phænomena* of Gravity better than the *Cartesian*; but must be confessed to be far short of its simplicity. It is hard to conceive these circular Motions of the ætherial Matter in all Directions; and even those who would give a reason for every thing by the impulse of ætherial Matter, are not satisfied with what *Huygens* has offered in favour of it.

Bulffinger, rejecting this complexity of Motion, starts a third System.

He will have it that the ætherial Matter moves at once round two Axes perpendicular to each other; and tho' this of its self is not easy to admit of, he supposes two other Motions of the ætherial Matter, contrary to the two Former. Here you have four *Vortices*, two against two, which cross each other without any interruption or disorder.

Thus is it that, by the *Vortician* System, they account for the two grand *Phænomena* of Nature,

That a fluid Matter circulating about sweeps the Planets around the Sun: that, in the particular *Vortex* of each Planet, a like motion of Matter impels Bodies towards the Center: Thoughts which naturally enough enter into the Mind.

But Nature more nicely examined will not suffer us to adhere to these first Notions. Those who enter into any Scrutiny of the thing, are obliged in the *Solar Vortex* to admit of the Interruption of the Motions of the several Beds we have mentioned; and in the *Terrestrial Vortex*, of all the contrary Motions in the ætherial Matter; and indeed 'tis at a very great disadvantage that a Man undertakes, to account for the *Phænomena* by the assistance of *Vortices*.

* *Bulfinger.*

Hence it is that an Author * we have often cited, says, That notwithstanding his endeavors to defend the *Vortices*, it may happen that those who reject them, may be the more obstinately bent against them by his manner of pleading for them.

It must be confessed that hitherto the *Vortices* have not been satisfactorily reconciled with the *Phænomena*; but we are not therefore to conclude the absolute impossibility of them; nothing can be finer than the Notion of *Descartes*, who would have every Thing, in Physics, explained by Matter and Motion; but to keep up the Beauty of this Notion, we must not go and suppose Matters and Motions, only because we stand in need of them.

Let us now see how Sir *Isaac Newton* accounts for the Motion of the Planets, and Gravity.

C H A P. V.

*The same Phænomena explained by
the Newtonian System.*

SIR *Isaac Newton* in the first place demonstrates, that if a Body in Motion be attracted towards a moveable or an immoveable Center, it must describe equal Area's, about that Center, in equal Times; and inversely if a Body describes equal Area's about a moveable or an immoveable Center in equal Times, it is attracted towards that Center.

This demonstrated by Arguments of the most sound Geometry, he applies it to the Planets, by him considered as moving in a void, or in spaces so thinly interspersed with Matter, as to be of no sensible Resistance to the Bodies that move therein: And it appearing by Observation that all the primary Planets revolve about the Sun, and all the Secondaries around their Primaries, in such a manner that they describe equal Area's in equal Times, he concludes that the Planets are attracted towards the Sun, and the *Satellites* towards their Principals respectively.

Whatever the Law of this Force which attracts the Planets, may be; that is, in what Degree

Degree soever it increases and decreases, according to the distances of the Planets, it in general suffices that they are attracted towards a Center, for the Area's they describe to be in proportion to the Times; but by this Proportion alone we cannot discover the Law of this Central Force.

But if one of *Kepler's* Analogies (thus it is they call that proportionality between the Area's and Times) points out a Central Force in general, this gives us the Law of this Force.

This other Analogy, as we have seen above, relates to the proportion between the Periodical Time of each Planet, and its distance from the Sun. The Periodical Times of the Planets about the Sun, and of the Secondaries about the Primaries, are as the square Roots of the Cubes of their distances from the Sun, or any Primary.

This Proportion between the Periodical Times and the distances once known, *Sir Isaac* inquires in what Degree, or by what Law the Central Force must increase and decrease, for Bodies that move by such a force in circular Orbits, or nearly circular, to observe this Proportion between the Periodical Times and the Distances; and by Geometry it is easily demonstrated that this other Analogy supposes the force that attracts the Planets towards the Center, or rather the Focus of the Curves they describe, to be in a reciprocal

reciprocal Proportion to the squares of their Distances from the Center, that is, it decreases as the squares of the Distances increase.

These two Analogies so difficult to reconcile according to the Doctrine of *Vortices*, are here Facts which discover to us this Central Force, and the Law of the same.

To suppose this Force and its Law, is not building a System; it is discovering the Principle whose Effects observed, are its necessary Consequences. Gravitation towards the Sun is not laid down to account for the Revolutions of the Planets; but the very Course of the Planets tell us there is a Gravitation towards the Sun, and what is its Law. Let us now see what use Sir *Isaac* is going to make of the Principle he thus discovers.

Assisted by the most sublime Geometry, he investigates the Curve which must be described by a Body, that with a rectilinear Motion at first, is diverted therefrom towards a Center, by a Force whose Law is such as he has discovered.

And the Solution of this fine Problem informs him that a Body must, in such a Case, necessarily describe some one of the Conic Sections, and that if the Course held by the Body returns into itself, as happens to the Planetary Orbits, this Curve must be an Ellipsis in whose Focus the Central Power must reside.

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If Sir *Isaac Newton* was indebted to the two first Analogies, for his discovery of attraction and its Law, he here sees them confirmed by new *Phænomena*: All Observations make it appear that the Planets do move in Ellipses, in whose Focus is the Sun.

The Comets so destructive to the System of *Vortices*, contribute to confirm the *Newtonian* System.

Sir *Isaac* having found that Bodies which move about the Sun, tend towards him, by a certain Law, or in a certain Proportion, and must describe some Conic Section, as do the Planets whose Orbits are Ellipses; considers the Comets as Planets that move by the same Law, whose Orbits are also Ellipses, but so very long that, without any sensible Error, they may be taken for *Parabola's*.

But he does not stop at this, tho' so much in favour of him, he must have some thing more certain and exact. It must be seen whether the Orbit of a Comet, determined by Points given in the first Observations, and attraction towards the Sun, will quadrate with the trace the Comet really describes in the remainder of its Course. To this purpose he calculated, he and the learned Astronomer Dr. *Halley*, the Orbits of the Comets by the Observations of which we are enabled to make the Comparison; and it cannot without astonishment be seen that the Comets have appeared in the points of their Orbits so determined, almost

most as exactly as the Planets appear in the Places of their Orbits, as settled by the common Tables.

This Theory seems to want nothing but a pretty long series of Observations, to bring us acquainted with each Comet, and to enable us to foretel its return, as we do that of the Planets to the same Points of the Heavens. But Stars, whose Revolutions, to all appearance, are of some Centuries Duration, seem but ill adapted for the Observation of Man whose Life is so short.

Here you have the Revolutions of the Planets and Comets, all the *Phænomena* made out by one single Principle; and may not the laws of Gravity be explained still by the same Principle?

Bodies fall towards the Center of the Earth; it is the attraction of the Earth which makes them fall; but this Explication is too vague.

If the quantity of the attractive Power of the Earth, were known by any indication besides the fall of Bodies, we might see whether the fall of Bodies, according to the known Laws, is the effect of this Power or Force.

We see that the Sun attracting the Planets, is the Cause why they move round him, as the attraction of the Primaries confines their Secondaries; now the Moon is the Earth's Secondary or *Satellite*, it is the attraction

traction of the Earth therefore that makes the Moon turn round us.

The Orbit of the Moon, and the Time it takes up in moving about the Earth are well known; and thence we may come at the space, attraction would draw the Moon through, towards the Earth, in a given time, if the Moon deprived of Motion should tend towards the Earth in a right line by the cogency of this same Force.

The mean distance of the Moon from the Earth being about 60 Semi-diameters of the Earth, it is by a ready Calculation found, that the degree of attraction the Earth exercises upon the Moon, in the region where she is, would make her fall through 15 Foot in a Minute.

But attraction increasing as the squares of the Distances decrease; if the Moon or any other Body were 60 times nearer to the Surface of the Earth than she happens to be, the attraction of the Earth would be 3600 stronger, and the Body would fall through 3600 times 15 Foot in a Minute; for Bodies, when they begin to move, run through spaces proportional to the moving Power.

Now, by *Huygens's* Experiments, we know the space a Body falls through, by its own Gravity meerly, towards the Center of the Earth; and this space is precisely the same as the Force which retains the Moon ought to
make

make a Body run through, increased as it ought to be towards the Center of the Earth.

The Fall of Bodies then towards the Earth is an effect of this same Force; whence we gather that the gravity of Bodies is the greater, the nearer they are to the Center, and so on inverfely; tho' the greatest Distances we can make Experiment upon are too inconsiderable for us to be sensible of this difference of Gravity.

Particular Experiments, have taught that the gravity of Bodies, caused by this attraction, at equidistance from the Center of the Earth, is as their quantities of Matter.

This Force then which attracts Bodies towards the Center of the Earth, acts proportionably upon all the parts of Matter.

Now attraction is always mutual or reciprocal; one Body cannot attract another without being proportionably attracted thereby. If the attraction of the Earth, upon every part of Matter be equal, every part of Matter attracts the Earth in its turn; and an Atom cannot fall towards the Earth but the Earth must rise to meet it.

Thus it is that the Motions of the Planets are amply illustrated by the Principle of attraction; and the gravity of Bodies is but a Consequence of the same.

I do not here speak of the very inconsiderable Anomalies, that may be either
passed

passed over, or explained by this Principle.

For Example, the Sun is supposed to be immoveable in the Focus of the Ellipses described by the Planets; and yet he is not absolutely immoveable; attraction being always mutual, the Sun cannot attract the Planets but he must be attracted by them: Strictly speaking, then the Sun continually changes Place according to the different positions of the Planets; so that it is only the Center of gravity of all the Planets and the Sun that is immoveable; but the enormity of the Sun is such to the Planets, that were they all together on one side, the distance of the Center of the Sun from the common Center of Gravity, which is then the greatest that can be, would not be one only of his Diameters.

The same is to be understood of every Planet that has *Satellites*: The Moon, for Example, so attracts the Earth that her Ellipsis about the Sun is not described by her Center, but by the common Center of Gravity of the Earth and Moon, while each of these Planets performs a Revolution about this Center of Gravity in the space of a Month.

The mutual attraction of the other Planets cause no sensible change in their Course; *Mercury*, *Venus*, the Earth, and *Mars*, are not so large as to be able to act upon each other to a degree of Sensibility. Their revolutionary

lutionary Motion can only be disturbed by *Jupiter* and *Saturn*, or some of the Comets who might cause some diversion in the Aphelia of these Planets, but so very inconsiderable and so slow as not to be minded.

But it is not so with the mutual attraction between *Jupiter* and *Saturn*; these two mighty Planets reciprocally disturb each other, when in Conjunction, and that, to a degree considerable enough to be observed by Astronomers.

Thus is it that attraction and its Law being once settled with regard to the Area's the Planets describe about the Sun, and the Times; and with regard to the Periodical times of the Planets, and their distances, the other *Phænomena* are but necessary Consequences thereof. The Planets must describe the Curves they do describe; Bodies must fall towards the Center of the Earth, and their fall must be as violent as it is; and in short the Planets are subject to such disturbances in their Course as must naturally result from this attraction.

One of the effects of attraction, namely, the fall of Bodies, is plain enough; but this effect even is what prevents us from discovering the attraction of Bodies towards each other. The Power or Force of attraction being as the quantities of Matter in Bodies, the attraction of the Earth upon every Body whatsoever, hinders our seeing the effects of

their own attraction; for urged towards the Center of the Earth by an immense Force, their mutual attractions become insensible, as a Storm destroys the lightest Breath.

But if we extend our View to what can manifest their attraction upon each other, we shall find the effects of attraction as continually repeated as those of Impulsion. The Motions of the Planets declare themselves every Instant, while impulsion is a Principle which Nature seems to employ but in small.

Attraction being no less possible in the Nature of Things than Impulsion, the *Phænomena* which indicate Attraction being as frequent as those that plead for Impulsion; when we see one Body tend towards another, to say that it is not attracted, but that it is pushed along by an invisible Matter, were much the same as if a favourer of Attraction, who should see one Body put in motion by another, should say it does not move by the effect of Impulsion, but by the attraction of some invisible Body.

I now leave the Reader to judge whether or no Attraction be sufficiently made out by Facts, or whether it is but a mere *gratis dictum* we may do without.

For my part I confess I know not what this gravity of Matter may be, and that I am as ignorant with reference to its impulsive Force. If it could be made out that the one depends upon the other, it would most assuredly

assuredly simplify the Systems; but in the mean time I believe that without preferring the one to the other, we may make use of both.

C H A P. VI.

Of the Differences wherewith the various Nature of Gravity must affect the Figure of Fluids, that turn about an Axis.

I Return now to consider what the several Systems may alter in the application I make of the following Problems to the *Phænomena* of Nature.

In these Problems I determine the Figure that ought to be assumed by a Mass of homogeneous and fluid Matter, which revolves about an Axis, or a torrent of the same Matter which turns around an Axis which is not its own, or taken without itself.

For Bodies to arrive at permanency of Figure, all their parts must be in perfect equilibrio. Now these parts are animated by two Forces, on which this *Æquilibrium* must depend; the one, the Centrifugal Force they acquire by their Revolution, tending to re-

move them from the Center ; the other, which is Gravity, tending thereto. As for the Centrifugal Force there is a perfect agreement about that ; it is no more than the Effort of all Bodies that circulate, to go wide of the Center of their Circulation ; and proceeds from the Force wherewith all Bodies endeavour to persevere in the state they are once in, of Rest or Motion. A Body forced to move in the direction of some Curve, continually endeavors to escape by the Tangent of that Curve ; because at every instant its state is to move in the strait direction of the very small right lines which compose the Curve, and whose prolongations are the Tangents. The nature then of this Centrifugal Force which is one of the Elements of the following Solutions, and its effects, are well known ; and the use I have here made thereof is liable to no Objection.

But it is not so with Gravity ; it is necessary to shew the alterations it may cause in the following Resolutions, according as it is considered either as an effect of Impulsion, or as a property of Bodies.

If Gravity be imputed to the impulse of some matter that drives Bodies downwards, as *Descartes* and *Huygens* suppose, the Force that so animates Bodies to tend towards the Center, will be independent of the Body that may be in the Center, and of its Figure ; if the Earth, for example, should not be in
the

the Center of the *Terrestrial Vortex*, or were of a different Figure from what it is, Bodies would nevertheless always tend to the Center of the *Vortex*, and with the very same rapidity as at present. Considering therefore, in these Problems, the gravity of the parts of Bodies, as inclining towards a Center independent of the figure of these Bodies, it is seen that the solution of these Problems must give the true Figures the cœlestial Bodies may be of, by fixing the Law according to which Gravity increases and decreases proportionably to the distance from the Center.

But if we consider Gravity as an inherent property in Matter, if the parts of Matter attract each other as the *Newtonians* teach, whence arises gravitation towards central Bodies; Gravity must then depend on their quantities of Matter and their Figures.

Sir *Isaac Newton* has demonstrated that spherical homogeneous Bodies, attract Bodies without them in a reciprocal proportion to the square of their distance from the Center; and that the gravity of their interior parts is as their distance from the Center. But in Bodies of different Figure, Gravity obeys not these Laws; it observes others that arise from the Figure of these Bodies. And hence Sir *Isaac* taking this into Consideration when he sought after the length of the Earth's Axis, and the Diameter of the Equator, found them

to be to each other as 229 to 230, a proportion different from *Huygens's* and ours.

What is here taught concerning the Figures of the Planets and the Suns, ought not then to be taken for absolutely granted. But if, as some Philosophers will have it, or as is very possible, there are, in Bodies, *Molæ* or Nuts of Matter much more dense than the rest; the parts without the Nut will gravitate towards its Center, nearly as Bodies gravitate towards the Spheres without which they are; and the Figures I determine will approach nearer to the true Figures. This ought to be still more considered with regard to the Atmospheres of the heavenly Bodies, the density of the Fluids that surround them being very inconsiderable in comparison of theirs.

The same is it with the *Vortices* which move around the Planets; they may be so very rare in proportion to the Planets, that the mutual gravitation of their parts may be passed over, and considered as nothing with regard to gravitation towards the Planets. Admitting therefore the matter of these *Vortices* as gravitating towards the Center of any Planet, in an inverse *Ratio* of the square of its Distance, the figure of the Rings they form, will come very near to truth.

C H A P. VII.

A Mathematical Inquiry into the Figures that must be assumed by Fluids, that revolve about an Axis.

P R O B L E M I.

To find the Figure of a fluid Spheriod that turns about its Axis, supposing every part of the Fluid to gravitate towards the Center, according to any power whatsoever of the distance from that Center.

S O L U T I O N.

LET PQ be the Axis of Revolution, and PAQB the section of the Spheroid by the Axis. Seeing the parts of the Fluid are at rest within themselves, every Column gravitates equally towards the Center C; taking then one of these Columns CD, which together with CP forms an Angle whose Radius being = 1, its Sine = b , I consider it as compounded of infinite small Cylinders Gg; and I want the gravity of each of them towards C.

C c 4

The

The absolute gravity being given in A, $=p$, to have the gravity in G, say $p. p :: CA^2 CG^2$, whence you have the Gravity in G, or

$$p' = \frac{p \cdot CG^2}{CA^2}$$

F I G. I.

But the revolutionary Motion actuating every Part of the Fluid with a centrifugal Force, according to GH, and in Bodies that perform their Revolutions in the same times, the centrifugal Force being as the Radii of the Circles they describe; if the centrifugal Force in A be given, and $=f$, to have the centrifugal Force in G, say $f.f' :: CA.LG =$ (because of $LG.CG :: b.1$) $b.CG$; whence you have the centrifugal Force in G, or $f' = \frac{f \cdot b \cdot CG}{CA}$: But this Force acting according to or in the Direction of GH, does not diminish the Force according to GC, but in that it acts in the contrary Direction according to GD. To find then this Force according to GD, you have GH, GK, or $1.b :: \frac{f \cdot b \cdot CG}{CA} . f'' = \frac{f \cdot b \cdot b \cdot CG}{CA} =$ to the Force which draws the small Cylinder according to GD.

The Force then that draws the small Cylinder
Gg

Gg according to GC, is then no more than $\frac{p \cdot CG^n}{CA^n} - \frac{fbb \cdot CG}{CA}$; and the Gravity of the

small Cylinder towards C, will be

$\left(\frac{p \cdot CG^n}{CA^n} - \frac{fbb \cdot CG}{CA} \right) Gg$. The Gravity of the

Column CG, compounded of these small Cylinders, will be then $\int \left(\frac{p \cdot CG^n}{CA^n} - \frac{fbb \cdot CG}{CA} \right) Gg$,

or $\frac{p \cdot CG^{n+1}}{(n+1) CA^n} - \frac{fbb \cdot CG^2}{2CA}$; and the weight of

the whole Column CD will be $\frac{p \cdot CD^{n+1}}{(n+1) CA^n} -$

$\frac{fbb \cdot CD^2}{2CA}$ which must be a certain Weight or Gravity A.

If then we make $CA=a$, $CD=r$, you will

have $\frac{pr^{n+1}}{(n+1)a^n} - \frac{fbbrr}{2a} = A$; and this Equation

taking place, let b be what it will, it is plain that b being supposed to be variable, the Equation will give the Proportion of every Radius CD and the Sine of the Angle it forms with the Axis PQ, and consequently give all the Points of the Curve.

We must now determine the certain Quantity

stry A. That the foregoing Equation may belong to the Section of the Spheroid whose Semi-axis $CA = a$; when the Angle DCP is right, or when $b = a$, r must be $= a$; then you have $\frac{p a^{n+1}}{(n+1)a^n} - \frac{f a^n}{2a} = A$ or $A =$

$$\left(\frac{2p - af - f}{2(n+1)} \right) a$$

So the Equation will stand thus $\frac{p r^{n+1}}{(n+1)a^n}$

$$- \frac{f b b r r}{2a} = \left(\frac{2p - af - f}{2(n+1)} \right) a, \text{ or } 2p r^{n+1} - (n+1)$$

$$f b b a^{n-1} r r = (2p - af - f) a^{n+1}.$$

This Equation gives the Sections of all the Spheroids, whatever may be the Power of the Distance with regard to Gravity, excepting the Hypothesis only of a Gravity which should be in a reciprocal Proportion to the Distance from the Center. In this Case we must recur to

$$\int \left(\frac{p \cdot CG^n}{CA^n} - \frac{f b b \cdot CG}{CA} \right) Gg, \text{ which then becomes}$$

$$\int \left(\frac{p \cdot CA}{CG} - \frac{f b b \cdot CG}{CA} \right) Gg, \text{ which is no longer integrable but by Logarithms. You have there-}$$

$$\text{fore } p \cdot CA \cdot l CG - \frac{f b b \cdot CG^2}{2CA}; \text{ or for the Weight}$$

$$\text{of the whole Column, } p a l r - \frac{f b b r r}{2a} = A.$$

To

To rectify this Equation, b must be $= 1$, and $r = a$; and then you have $pala - \frac{fa}{2} = A$; and corrected, $palr - \frac{fbhrr}{2a} = pala - \frac{fa}{2}$; or $2pal$
 $\left(\frac{r}{a}\right) = \frac{fbhrr}{a} - fa$; or, going to Numbers, and taking c for the Number whose Logarith. $= 1$,
 you have $r = ac \left(\frac{fbhrr}{2paa} - \frac{f}{2p}\right)$.

It is evident that the Meridians of the Spheroids are continually Algebraic Curves, except in this one Hypothesis.

If you would have the Equation of all these Curves in the common way, by co-ordinate Rectangles, it is easily done. For, making $CE = x$ and $DE = y$, you will have $rr = xx + yy$, and $br = y$. Striking out b and r from the general Equation, you

will have $2p (xx + yy)^{\frac{n+1}{2}} - (n+1)fa^{n-1}yy$
 $= (2p - nf - f) a^{n+1}$: and for the Case
 $n = -1$, $xx + yy = aac \left(\frac{fyy}{paa} - \frac{f}{p}\right)$

But our first Method of finding the Curves, by Radii and Angles, is in this Case rather the more convenient of the two.

Though

Though we suppose b to be variable, it nevertheless varies but within certain Limits which are 0 and 1; the radial Equation then only determines the Arc of the Curve whose Amplitude is a Right-angle: But these Curves being compounded of four similar and equal Arcs; they are entirely ascertained by our Equation.

We may now readily come at the Proportion between the two Axes of the Section, in any Hypothesis whatsoever.

The general Equation being $2pr^{n+1} - (n+1)fbka^{n-1}rr = (2p-nf-f)a^{n+1}$; to find r when $b=0$, you have $2pr^{n+1} = (2p-nf-f)a^{n+1}$. Whence you deduce CA

$$CP :: (2p)^{\frac{1}{n+1}} \cdot (2p-nf-f)^{\frac{1}{n+1}}.$$

And in the Hypothesis of a Gravity in an inverse Ratio of the simple Distance you have

$$l\left(\frac{r}{a}\right) = \frac{f}{2p}. \text{ Whence you deduce } ICA - ICP = \frac{f}{2p}.$$

It is plain that n being a positive Number, whether an integer or not, that is, in all the Hypotheses of a Gravity in a direct Ratio of any Power whatsoever of the Distance, the Diameter of the Equator will always exceed the Axis of Revolution. But if n be a negative Number, that is if Gravity be in an Inverse Ratio of any Power of the Distance,

stance, you will have $CA . CP :: (2p)^{\frac{1}{-n+1}}$

$\cdot (2p + nf - f)^{\frac{1}{-n+1}}$; now if $n < 1$, let $k = 1 - n$,

and you will have $CA . CP :: 2p^{\frac{1}{k}} \cdot (2p - kf)^{\frac{1}{k}}$;

and if $n > 1$, let $n - 1 = k$, and you will have

$CA . CP :: (2p)^{\frac{1}{-k}} (2p + kf)^{\frac{1}{-k}}$, or $CA . CP ::$

$(2p + kf)^{\frac{1}{k}} \cdot (2p)^{\frac{1}{k}}$. We have moreover

seen that n being $= -1$, you have $l\left(\frac{CA}{CP}\right) = \frac{f}{2p}$.

Whence it is plain that there is no Hypothesis wherein the Spheroid is not flat at the Poles.

SCHOLIUM.

The Figure of the Spheroids depends then on the proportion between the Centrifugal Force and gravitation. Let us now see to what Degree this proportion may vary in some Hypotheses of Gravity, and what Figures would thence result in the Spheroids.

If we suppose Gravity to be uniform; n being $= 0$, you have $CA . CP :: 2p \cdot 2p - f$. Upon our Earth the force of Gravity is 289 times greater than the Centrifugal Force under the Equator; if then we would have the proportion between the Diameter of
the

the terrestrial Equator and the Axis of Revolution, in this Hypothesis of a uniform Gravity, substituting 289 for p , and 1 for f , you will have $CA . CP :: 578 . 577$.

The centrifugal Force might be equal to Gravity, which would actually happen if the Earth revolved 17 times faster than at present; and then you would have $CA . CP :: 2p . p :: 2 . 1$. The Centrifugal Force could not be greater without dispersing the parts of the Earth; and if the revolutionary Motion should continue to accelerate, the Earth would be reduced to a single Atom at the Center. Whence it is evident that in this Hypothesis of an uniform Gravity, the flattest Figure the Spheroid is capable of, could not make the Diameter of its Equator exceed the double of its Axis of Revolution. In this Case the Earth could be compounded of two Paraboloids, as *Huygens* has demonstrated in his Treatise of Gravity, p. 157. with regard to this Hypothesis, the only one he examined.

This Hypothesis, the most simple of all, is not to be taken for the only one; for *Herman* in his investigation of the Figure of the Earth, supposes a Gravity in proportion to the distance from the Center. * Let us now see what might happen in this Hypothesis, and what Figure it might give to the Spheroids.

* *Phoron.*
p. 366.

You have then ($n = 1$) $CA . CP :: \sqrt{2p} . \sqrt{(2p - 2f)} :: \sqrt{p} . \sqrt{(p - f)}$; and if the Centrifugal Force became equal to Gravity, the Diameter of the Equator would infinitely exceed the Axis of Revolution; that is, the Spheroid would be reduced to a circular Plane. It being, in this Hypothesis, possible for the Centrifugal Force to be in all proportions with the force of Gravity, or Gravitation, from 0 to equality, the Diameter of the Equator may consequently be in all proportions with the Axis of Revolution. And the Spheroid which in this Hypothesis is an Ellipsoid, may be all the Ellipsoids from the Sphere to the flattest Ellipsoid, which would be no more than a circular Plane. But, according to this Hypothesis also, the Centrifugal Force cannot exceed the force of Gravity.

If we suppose Gravity to be in an inverse Ratio of the square of the distance from the Center conformably to the *Newtonian* Doctrine, you have $n = -2$; and $CA . CP :: (2p)^{-1} . (2p + f)^{-1}$; or $CA . CP :: 2p + f . 2p$. whence it appears that the Spheroid that continually flattens as the Centrifugal Force increases, will nevertheless be the flattest possible, when the Diameter of its Equator is to its Axis of Revolution as 3 to 2.

PRO-

Figures of the
P R O B L E M II.

A Torrent or *Vortex* of fluid Matter circulating about an Axis without the Torrent, by a centripetal Force in proportion to any Power whatsoever m of the distance from the Center measured from the Axis; and in each Section perpendicular to the Revolution, the Gravity resulting from the parts of the Fluid towards a Center taken within that Section, being equal to any power whatsoever n of the distance from that Center; to find the figure of the Torrent?

S O L U T I O N.

Let $ADPadQA$ be the Section of the Torrent that turns around the Axis $\lambda\lambda$, made by a Plane perpendicular to the Revolution, through the Center γ . Let γ be the Center of the centripetal Forces taken without the Torrent, and C the Center towards which is the Attraction resulting from the Part of the Fluid taken within the Section.

For the parts of the Fluid to be in equilibrium the weight of each Column CD , as well that which proceeds from the Gravitation towards γ and towards C , as well as the centrifugal Force must be every where the same.

Let then the absolute Gravity in A towards γ be given, and $=\pi$; let the Gravity in A towards C be also given, and $=p$; let also the

the Centrifugal Force in A be also given, and $=f$. Let $AC=a$, $C\gamma=b$, $CG=r$; the Sine of the Angle $DCP=b$, the Radius being $=1$; you will have $GL=br$; and taking away from γ the right Line γR perpendicular to the Radius CD continued, you will have $CR=bb$, and $\gamma G=\sqrt{(bb+2bbr+rr)}$.

Now the Gravity in A towards γ being $=\pi$; making $\pi \cdot \pi' :: (a+b)^m \cdot (bb+2bbr+rr)^{\frac{1}{2}m}$; you will have the Gravity in G, or π' .

$$= \frac{\pi(bb+2bbr+rr)^{\frac{1}{2}m}}{(a+b)^m}; \text{ and to have the Force}$$

which thence results towards C, say $\pi' \cdot \pi'' ::$

$$G\gamma \cdot GR, \text{ or } \frac{\pi(bb+2bbr+rr)^{\frac{1}{2}m}}{(a+b)^m} : \pi'' :: (bb+$$

$2bbr+rr)^{\frac{1}{2}} \cdot bb+r$; whence you will see the Force towards C resulting from the Gravitation

$$\text{towards } \gamma, \text{ or } \pi'' = \frac{\pi(bb+r)(bb+2bbr+rr)^{\frac{m-1}{2}}}{(a+b)^m}.$$

You have moreover (the Gravity in A towards C being $=p$) the Gravity in G towards

$$C, = \frac{pr^n}{a^n}; \text{ the whole weight then towards}$$

C, resulting from the two Gravities toward

ward γ and toward C, will be then =

$$\frac{\pi (bb+rr) (bb+2bbr+rr)^{\frac{m-1}{2}}}{(a+b)^m} + \frac{pr^n}{a^n}.$$

The centrifugal Force in A being $=f$; if you make $f \cdot f' :: a+b \cdot b=br$, you will have the centrifugal Force in G or $f' = \frac{f(b+br)}{a+b}$; and to find that part of this Force that draws towards D, say $f' \cdot f'' :: GH \cdot GK$, or $\frac{f(b+br)}{a+b} \cdot f'' :: 1 \cdot b$; whence, for the Force contrary to the Gravity toward C, you have $f'' = \frac{fb(b+br)}{a+b}$.

You have then for the Force towards C, resulting from all these Forces

$$\frac{\pi (bb+rr) (bb+2bbr+rr)^{\frac{m-1}{2}}}{(a+b)^m} + \frac{pr^n}{a^n} - \frac{fb(b+br)}{a+b}.$$

Conceiving then, as in the first Problem, the Column CD to be compounded of infinite small Cylinders dr , you will have

$$\int \left[\frac{\pi (bb+rr) (bb+2bbr+rr)^{\frac{m-1}{2}}}{(a+b)^m} + \frac{pr^n}{a^n} - \frac{fb(b+br)}{a+b} \right] dr,$$

which must be a certain Weight. Then you will

will have $\frac{\pi (bb+2bbr+rr)^{\frac{m+1}{2}}}{m+1(a+b)^m} + \frac{pr^{n+1}}{n+1.a^n} - \frac{fbbr}{a+b}$
 $-\frac{fbbr}{2(a+b)} = A.$

To correct this Equation, when $b=1$, r must be $=a$; and then you have $\frac{\pi(a+b)}{m+1} + \frac{pa}{n+1} - \frac{fab}{a+b} - \frac{faa}{2(a+b)} = A.$ And then the Equation

will stand thus, $\frac{\pi (bb+2bbr+rr)^{\frac{m+1}{2}}}{m+1(a+b)^m} + \frac{pr^{n+1}}{(n+1)a^n}$
 $-\frac{fbbr}{a+b} - \frac{fbbr}{2(a+b)} = \frac{\pi(a+b)}{m+1} + \frac{pa}{n+1} - \frac{fab}{a+b} - \frac{faa}{2(a+b)}.$ Or (changing c for $a+b$, and q for $(m+1) \times (n+1)$).

$$2(n+1)\pi a^n \times (bb+2bbr+rr)^{\frac{m+1}{2}} + 2(m+1)pc^m r^{n+1} - 2qfa^n bc^{m-1}br - qfa^n c^{m-1}bhrr = 2(n+1)\pi a^n c^{m+1} + 2(m+1)pa^{n+1}c^m - 2qfa^{n+1}bc^{m-1} - qfa^{n+2}c^{m-1}.$$

You see that in all these Hypotheses the Section of the Torrent is an Algebraic Curve, excepting the Hypotheses of an Attraction toward γ or towards C in a simple inverse Ratio of the Distance.

D d 2

For

For if only $m = -1$, the Equation of the Section of the Torrent will be $\frac{\pi(a+b)}{2}$

$$\begin{aligned}
 & L(bb + 2bbr + rr) + \frac{pr^{n+1}}{(n+1)a^n} - \frac{fbbr}{a+b} - \frac{fbbr}{2(a+b)} \\
 &= \frac{\pi(a+b)}{2} l(a+b)^2 + \frac{pa}{n+1} - \frac{fab}{a+b} - \frac{faa}{2(a+b)} \\
 \text{Or } \frac{\pi c}{2} l\left(\frac{bb + 2bbr + rr}{cc}\right) &= -\frac{pr^{n+1}}{(n+1)a^n} + \frac{fbbr}{c} + \\
 & \frac{fbhrr}{2c} + \frac{pa}{n+1} - \frac{fab}{c} - \frac{faa}{2c}.
 \end{aligned}$$

And if only $n = -1$, the Equation will be

$$\begin{aligned}
 & \frac{\pi(bb + 2bbr + rr)}{m+1(a+b)^m} + palr - \frac{fbbr}{a+b} - \frac{fbhrr}{2(a+b)} \\
 &= \frac{\pi(a+b)}{m+1} + palr - \frac{fab}{a+b} - \frac{faa}{2(a+b)} \quad \text{Or} \\
 & pal\left(\frac{r}{a}\right) = -\frac{\pi(bb + 2bbr + rr)}{(m+1)c^m} + \frac{fbbr}{c} + \\
 & \frac{fbhrr}{2c} + \frac{\pi c}{m+1} - \frac{fab}{c} - \frac{faa}{2c}.
 \end{aligned}$$

But if at the same time $m = -1$ and $n = -1$, the Equation will be

$$\begin{aligned}
 & \frac{\pi(a+b)}{2} l(bb + 2bbr + rr) + palr - \frac{fbbr}{a+b} - \\
 & \frac{fbhrr}{2(a+b)} = \frac{\pi(a+b)}{2} l(a+b)^2 + palr - \frac{fab}{a+b}
 \end{aligned}$$

$$-\frac{faa}{2(a+b)}. \text{ Or } \frac{\pi c}{2} l \left(\frac{bb+2bbr+rr}{cc} \right) + pal \left(\frac{r}{a} \right) \\ = \frac{fbbr}{c} + \frac{fbhrr}{2c} - \frac{fab}{c} - \frac{faa}{2c}.$$

If you would have the Section of the Equation by co-ordinate Rectangles; by making $CE=x$ and $DE=y$, you will have the two Equations $rr=xx+yy$, and $br=y$; so that striking out r and b from the foregoing Equations, you will, for the general Case, have

$$2(n+1) \pi a^n (bb+2by+yy+xx)^{\frac{m+1}{2}} + 2(m+1) \\ pc^m (xx+yy)^{\frac{n+1}{2}} - 2qfa^n bc^{m-1}y - qfa^n c^{m-1}yy = \\ 2(n+1)\pi a^n c^{m+1} + 2(m+1)pa^{n+1}c^m - 2qfa^{n+1}bc^{m-1} - qfa^{n+1}c^{m-1}.$$

In the same manner you may have the Equations, in the Cases $m=-1$ and $n=-1$.

You will also find the Curve PaQ as we have found the Curve PAQ , by observing the proper Changes.

For then if the Gravity in a towards γ be given and $=\pi$, the Gravity in a towards $C=p$, the centrifugal Force in $a=f$, $Ca=a$, $C\gamma=b$, $Cg=r$, $gl=br$, $Cr=bh$, and $\gamma g = \sqrt{(bb-2bbr+rr)}$; you will have the Gravity in g towards C resulting from the Attraction

$$\text{towards } \gamma, \pi'' = \frac{\pi (bb-r)(bb-2bbr+rr)^{\frac{m-1}{2}}}{(b-a)^m}.$$

You

You have moreover the Gravity in g towards

$$C, p' = \frac{p r^n}{a^n}.$$

You will also have the part of the Centrifugal Force which results in g towards C ,

$$f'' = \frac{f b (b - b r)}{b - a}.$$

But these two last forces are contrary to the first; you will then have,

$$\int \left[\frac{\pi (-bb + r) (bb - 2bbr + rr)^{\frac{m-1}{2}}}{(b-a)^m} + \frac{p r^n}{a^n} + \frac{f b (b - b r)}{b - a} \right] dr = A. \text{ Whence you have}$$

$$\frac{\pi (bb - 2bbr + rr)^{\frac{m+1}{2}}}{m+1 (b-a)^m} + \frac{p r^{n+1}}{(n+1) a^n} + \frac{f b b r}{b-a} - \frac{f b b r r}{(2b-a)} = \frac{\pi (b-a)}{m+1} + \frac{p a}{n+1} + \frac{f a b}{b-a} - \frac{f a a}{(2b-a)}.$$

And in the Cases of $m = -1$, $n = -1$, you will have, as above, the Equation of the Sections that will only differ by the Alteration of some Signs.

By these radial Equations you will have the Equations from the Co-ordinates, as was done for the Curve PAQ.

And the Weight of the Column, as well in the Superior Curve as the Inferior, being continually the same, you will have an Equation be-

between the Weight A in the Superior Curve, and the Weight A in the Inferior, by which you may find the Proportion between Ca and CA; and thus you may determine the entire Section of the Torrent.

SCHOLIUM.

Let the Hypothesis of Gravity be what it will, you may always, for a certain Angle DCP, so contrive that the Radius CD be of a given Length: And by that means make the Figure of the Torrent more or less oblate, infinite ways, by substituting determinate Quantities or Values instead of b and r . Thus you may contrive that the Points P and Q shall meet in C, by substituting 0 for b and r ; and then the Section of the Torrent, will be compounded of two Oval Figures joined in C. You will find infinite Proportions between π , p and f , that will give this Figure.

If for Example, you would have the Points P and Q fall in C; you will have

$$2(n+1)\pi b^{m+1} = 2(n+1)\pi c^{m+1} + 2(m+1)pac^m - 2qfab c^{m-1} - qfaac^{m-1}.$$

Whence you may deduce infinite Proportions between π , p and f .

If we suppose the Gravity as well towards γ as towards C, in a simple Proportion of the

D d 4

Distance

Distance from the Center ; the Section of the Torrent will be a Conic Section. And if it should be moreover required that the Points, P, Q and C unite, the Figure will be compounded of two Ellipses conjoined in C.

If the Distance Cy vanishes, or if the two Centers unite, you will have $b=0$ and $c=a$, and the Torrent will become a Spheroid.

If moreover we suppose $m=n$ and $\pi=0$; the general Equation of the Section of the Torrent will become $2pr^{n+1} - (n+1)fa^{n-1}bkr = (2p - nf - f)a^{n+1}$. Or in the Case of $n = -1$; $2pal\left(\frac{r}{a}\right) = \frac{fbkr}{a} - fa$, as in the first Problem, which is but a particular Case of this.



C H A P. VIII.

Of the Figures of the Cælestial Bodies ; of the Stars which seem to alter their Magnitude, and of Saturn's Ring.

ALL we have been saying is self applicable to the Cœlestial Bodies that turn about an Axis, if we suppose their parts to have taken the exact place which Gravity and the Centrifugal Force allotted them.

All the Planets, we know, are very nearly Spheres, excepting *Jupiter* whose Oblateness is considerable enough to be observed by Astronomers ; but they are not therefore the less liable to all the Figures we have mentioned : There needs only less density in the Matter they are compounded of, or more Rapidity in their Revolution, to make them assume all these Figures : And why should the kind of uniformity we see in some Planets prevent us from suspecting, at least, the variety of those, the immensity of the Heavens, perhaps, hides from our Sight. Confined to a corner of the Universe, with circumscribed Intellects, why should we bound Things to the little we perceive ?

We

We have seen that Spheroids may assume infinite Figures, according to the Gravity of their parts and their Centrifugal Force; and that, in several Hypotheses, a Planet may from a Spheroid the least oblate, take on it the Figure of a Molary or Millstone, or be reduced even to a circular Plane. Perhaps it is the distance only that hinders our seeing of such Planets. But even without being at any very great distance from us, they may be hid from our Sight, if their Orbits happening to be in the Plane of the Ecliptic, or but a little distant from it, the Axis of their Revolution should be perpendicular, or nearly so, to the same Plane. Supposing this, the Earth being always in the Plane, or nearly so, of the Equator of these Molaries, their thinness would conceal them from our Eyes.

Here then you have a new kind of Planets in the Heavens; at least, such there may be: But let us push the thought a little farther.

The fixed Stars are Suns like ours; it is very possible then, that like ours they revolve about an Axis. They must then according to the Rapidity of their Motion, be subject to a flat Form; and why should there not be such very oblate Stars in the Heavens? especially if it be considered that we by no Observation have come at the precise Figure of the fixed Stars.

But

But again, it is very probable that the fixed Stars have their Planets that move round them, as our Sun has his.

If then any mighty and very excentric Planet or Comet should go round a flat Star, in an Orbit inclined to the plane of the Equator of the Star, what would happen? The gravitation of the Star towards the Planet, when near its *Perihelion*, would alter the inclination of the said Star, which must therefore appear more or less luminous. Such a Star even as we perceive not, because its edge is towards us, will be visible when it shews us a part of its disc; and having made its appearance would disappear again. Thus is it we may account for the change of Magnitude observed in some Stars, and for Stars that have appeared and disappeared.

The Comets are no more, as we have seen, than very excentric Planets, some of which having bordered very near upon the Sun, leave him again, traversing the Orbits of the more regular Planets, and then hold on their Journey through the different Regions of the Heavens.

When they return from their *Perihelion* they sweep long Tails after them, and these Tails are immense Torrents of Vapour which the heat of the Sun has raised from them.

If a Comet in this State should pass by some mighty Planet, the force of Gravity towards

towards the Planet might divert this Torrent, and bring it to circulate about itself, in the direction of some Ellipsis, or some Circle. And the Comet continuing to supply fresh Matter, or that already supplied, being sufficient, a continued flux of Matter would be formed, or a kind of Ring about the Planet.

The Planet will attract the Matter of this Torrent in a reciprocal proportion to the Square of its distance; but, within the Torrent there will be a second Gravitation of its parts mutually. In short the parts of the Torrent will have still a third Force, or a Centrifugal Force which they will acquire from their revolutionary Motion.

Now altho' the Body of Matter, that forms the Torrent, be at first Cylindrical, or Conic, or of any other Figure possible; it will necessarily assume some Figure bordering upon those I have determined in the second Problem. The Centrifugal Force will continually tend to flatten the Ring, and may be such, as well with regard to the Gravitation towards the Planet, as of the parts mutually within themselves, that the thickness of the Ring shall be very inconsiderable, in comparison of its breadth.

In the mean time, the Body even of the Comet may be attracted also to the Planet, and be forced to move round it.

What I have here said of oblate Planets that may perhaps be in the System of the World,

World, amounts to no more than to pretty probable conjecture on their existence. Tho' these Planets are not obvious to the Sight, the Mind may conceive them, and from the Laws of Gravity conclude there may be such.

And these conjectures concerning flat Stars, in particular, are rather the stronger, for that besides the possibility of the Thing, *Phænomena* seem to insinuate that there are in reality such Stars in the Heavens.

But as for Torrents that circulate about Planets, we seem to have nothing but bare conjecture to support us concerning them. We have sight of a Planet, with regard to which every thing seems to have hapned as I have surmised; nor ought we to wonder if we saw Planets environed with several Rings like that of *Saturn*.

These Rings ought rather to be formed around the great Planets than the small, seeing they are formed by Attraction which is stronger in the former than the latter: they ought also to be formed about the Planets far distant from the Sun rather than about those that are nearer; because, in those distant parts, the velocity of the Comet slackens, and consequently gives the Planet a longer time to exercise its power, and with the greater effect upon the Torrent or Tail.

Nor is this a little confirmed by Experience; the only Planet we see begirt with a Ring,

Ring, is one of the largest, and the farthest distant from the Sun.

The number of *Satellites* belonging to *Saturn* and the vastness of his Ring, may make us fancy he acquired them at the Expence of several Comets. In truth, this Ring, as thin as it seems to be, must be formed of a prodigious quantity of Matter to be able to cast such a shadow upon the disc of its Planet, as is observed by Astronomers; while the Tails of the Comets are so very rare, that you commonly see the Stars through them; but indeed the Gravitation the Matter of these Tails acquires towards the Planet that might divert them, and force them to fluctuate about it, must condense them.

As for the Planets that have *Satellites* and no Ring; it is plain that the Tail of a Comet being merely accidental, and common only to those that have been very near the Sun, a Comet without a Tail may become the *Satellite* of a Planet, without communicating a Tail to it. It is possible also that a Planet may acquire a Ring without a *Satellite*, if the Planet is at that distance from the Comet, that it can only attract the Tail to it.

The matter that forms these Rings, instead of being sustained as a Vault at a certain distance, may every way overflow the Body about which it revolves, and form a kind of oblate Atmosphere; and what may happen to the
the

the Planets, may in like manner happen to the fixed Stars. It is to such an Atmosphere about the Sun, that they attribute the light *Cassini* * observed in the *Zodiac*.

Sir *Isaac Newton* has observed that the Vapour of the Comets might spread itself over the Planets that should be near enough; and thinks this kind of Communication to be of use in restoring the Planets to the Humidity they incessantly lose. He even thinks the Comets may fall into the Sun or into the Stars; and thus it is he explains how it is that a Star ready to go out, supplied with such Fuel shines forth again with its first splendor. The famous *English* Philosophers, Dr. *Halley*, and Mr. *Whiston*, have taken notice that if a Comet should interfere with our Earth, terrible accidents might ensue, a change of Poles, Subversion, Deluge, and Conflagration; but instead of these fatal Catastrophes, the meeting with Comets might be productive of new wonders, and Things greatly useful to our Earth.

* *Mem. de l'Acad. des Sciences depuis 1666, jusqu'à 1699. Tom. VIII. Seconde Edition.*

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